POWER PLANT ENGINEERING

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More Power for Automobile Building

NEW PLANT OF CADILLAC MOTOR CAR CO. EXEMPLIFIES MODERN ISOLATED PLANT PRACTICE; HOT WATER EMPLOYED FOR HEATING LARGE WORKS; INTERESTING ELECTRICAL SYSTEM INSTALLED

APPRECIATING the advantages to be secured by a concentration of all manufacturing processes, the Cadillac Motor Car Co., of Detroit, Michigan, a subsidiary of the General Motors Corporation, some time ago formulated plans for the erection of a works by means of which it will be possible not only to increase materially the number of cars manufactured (ultimate capacity to be approximately 100 cars per day), but will also tend towards a higher degree of manufacturing efficiency and consequently a reduced cost of production per car. This new works, now in course of construction, is, as shown in Fig. 8, located on a triangular plot of ground bounded by the tracks of the Michigan Central Railroad, those of the Lake Shore & Michigan Southern Railroad and by Scotten Ave. on the west, the total space covered by the property being about 46 acres. Officially this will be known as the Clark Ave. Plant of the Cadillac Motor Car Co., this due to the fact that this thoroughfare passes directly through the works.

Essentially this will be a complete manufacturing plant, although up to the time of writing but five buildings—the power plant, the machine group, the car and stock storage, loading docks and an assembly and paint group—are complete and occupied. Ultimately nine buildings will comprise the works. Those on the east side of Clark Ave. will be the administration building and garage, covered loading docks, a storage and service stock building four stories high and the present assem-

FIG. 1. INTERIOR ENGINE ROOM CLARK AVE. CADILLAC WORKS

bly and paint building which is of like height. The other buildings are located opposite these, on the east side of the street.

With the location selected and arrangement employed, an ample supply of both skilled and unskilled labor will at all times be available and the receipt of raw material and the shipment of the finished product will be facilitated with dispatch. Fuel both for power production and that required for manufacturing purposes will be readily available through the rail facilities at hand.

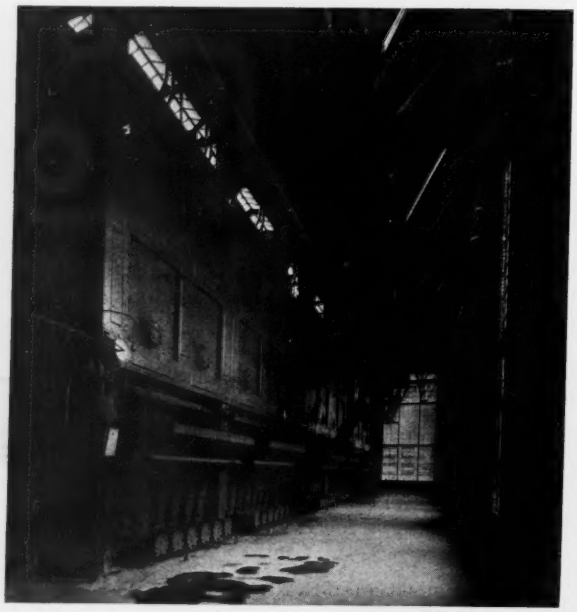


FIG. 2. FIRING AISLE, CADILLAC PLANT

All permanent buildings already erected, those now under construction and those contemplated are of steel, concrete and brick, thus rendering them entirely fireproof. The style of architecture employed, while plain, is pleasing to the eye and exemplifies on the whole the modern and up-to-date manufacturing plant.

Naturally, as may be expected, a works of this kind embodies many features of interest aside from those of the actual production of motor cars. Power is required for the operation of the shops, compressed air is necessary for the many pneumatic tools employed and artificial light, heat, pure cold drinking water and fresh air so conducive to the health and comfort of the employes are provided in abundance. The methods of generating and distributing these at the Cadillac plant are not only interesting, but also in some instances novel and unusual. This is particularly true of the electric distribution and the heating system.

The Power Plant

This building, which is situated at the northwest end of the property near the intersection of Clark Ave. and the tracks of the Lake Shore & Michigan Southern Railroad, consists primarily of an engine room and a boiler room and has overall dimensions of approximately 160 by 119½ ft. In conformity with the general scheme employed throughout the works, it is of steel and concrete construction and externally faced with a pressed brick dark red in color. The engine room in particular which faces on Clark Ave. is a thing of beauty and will, undoubtedly, upon completion of the Cadillac plant, prove a point of unusual interest to visitors. Only those portions of the outside walls necessary to provide the required rigidity of the structure are solid. The major part of the walls, as shown in Fig. 3, are of plate glass. The interior of the engine room, except for the finished ceiling which conceals the steel work, is finished in white glazed brick which, together with a floor of red tiling and dark colored machinery, gives to the whole a very harmonious and pleasing appearance.

Other parts of the plant such as the boiler room, the pump room, the transformer and switch room, etc., are finished in red brick and, except in the boiler room, are painted white. In the boiler room steel stairways and galleries give ready access to all pipe lines, boiler tops and the overhead bunkers and coal conveying and distribution equipment.

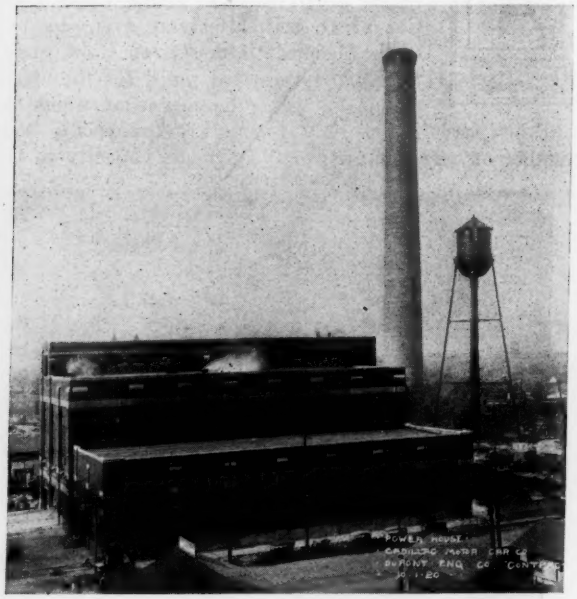


FIG. 3. EXTERIOR VIEW OF NEW CADILLAC POWER HOUSE

Ample space has been provided surrounding the power house for future additions to the building and a yard for the storage of coal.

For Handling the Fuel

Study of Fig. 9, illustrating in plan and sectional views the coal and ash handling systems, indicates the extent to which means have been employed to insure an ample supply of fuel at all times both for storage purposes and immediate use. Cars delivering the coal are run over a duplex, reinforced concrete, dumping and digging pit and there emptied. The coal may then be either delivered to the plant bunkers or to the storage yard for the purpose of which a 15-ton, 50-ft.-radius locomotive crane has been provided. With the arrangement of trackage employed the coal may be stored without rehandling in piles of 900, 2200 and 8000 tons and with rehandling in piles of 1400 and 1500 tons, thus

giving a total available storage which may be handled with the locomotive crane of 14,000 tons.

Maximum height of storage piles employed is 25 ft., being of the form shown in Fig. 9.

That coal not placed in storage is fed through the gates of the dumping and digging pits and by means of a 36-in. apron feeder 32 ft. long traveling at a speed of 15 ft. per minute and operated by a 7½-hp. motor is delivered to a 30 by 30-in. double-roll 90-r.p.m. crusher. This crusher is driven by a 25-hp. motor. The coal is then taken up by an 18-in. belt conveyor, 103 ft. in length, and delivered to the buckets of a 24 by 24-in. bucket conveyor and elevator which in turn delivers it to a second 18-in. belt conveyor 142 ft. long carried over to the boiler-room bunkers. Five 15 and 7½-hp. motors are used for the operation of the lower belt conveyor, the bucket elevator and the bunker belt conveyor, respectively. The latter travels at a speed of 300 ft. per minute.

A traveling crane weigh larry having a maximum capacity of 2 t. and operated by a 3-hp. motor is used to weigh and deliver the coal to the stoker hoppers.

The capacity of the coal handling equipment is 75 tons per hour; that of the overhead boiler room bunkers is about 1500 tons.

Ash and other furnace residue as discharged by the stoker grates is deposited in concrete receiving pits from where, at stated intervals, it is removed, dumped into four-wheel cars, each having a capacity of 27 cu. ft. and in these carried to a skip hoist which elevates it to cars or trucks. The scheme of arrangement employed is well shown at the left of Fig. 9.

In the Boiler Room

Although no electric energy is generated at the Cadillac works, large quantities of steam are required for numerous purposes such as the operation of air compressors, a complete absorption type of refrigeration system, the heating of water for domestic and building heating purposes and the operation of many pieces of auxiliary apparatus installed in and about the power house.

The present steam-generating equipment consists of six water-tube boilers each with a heating surface of 6032 sq. ft., 452 3¼-in. tubes and 7-in. steam outlets. These units, which are equipped with six retort underfeed automatic cleaning stokers with active grate areas per boiler of 88 sq. ft. and a capacity of 4800 lb. of coal per hour at 200 per cent capacity, have a nominal rating of 603 hp. and are designed and constructed for a working pressure of 165 lb. gage.

FIG. 4. BOILER ROOM BASEMENT SHOWING ASH HOPPERS AND FORCED DRAFT FANS

Future plans call for the installation of two additional boilers and the changing over of one of the coal fired units to provide for wood-burning, thus enabling the utilization of the wood-shop waste as fuel. This change is, however, not to be made until the body building plant is in operation.

Forced draft is employed in connection with the stokers. This is supplied by three heavy-duty fans, two of which are capable of delivering 66,000 cu. ft. of air per minute when driven at a speed of 1200 r.p.m. by 125-hp. steam turbines to which they are direct connected; the other is rated at 34,000 cu. ft. of air per minute at 1400 r.p.m. and is connected through reduction gearing to a 70-hp. steam turbine. These fans, each

of which is under automatic steam control, discharge into a 5 by 10-ft. metal duct connecting with the air chambers under the stokers. The static pressure is 6 in. of water.

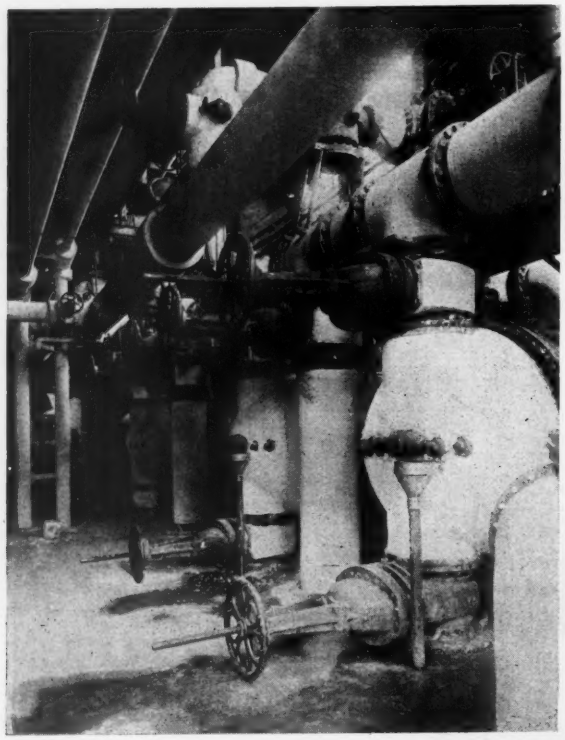


FIG. 5. HOT WATER HEATERS AND PIPING

Furnace gases from the last passes enter a tapering sheet metal breeching having minimum dimensions of about 5 by 8 ft. and maximum dimensions of approximately 8 by 18 ft. and are from there carried to the

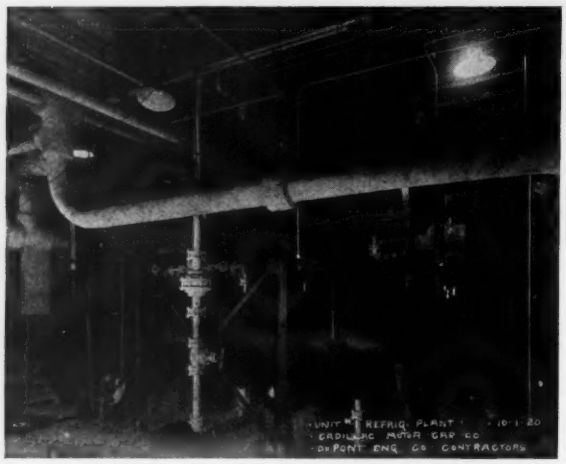


FIG. 6. UNIT 1, REFRIGERATION PLANT

atmosphere by means of a radial buff brick Custodis chimney having a height of 209 ft. above the boiler room floor, an inside top diameter of 14 ft. and an outside bottom diameter of 22 ft. 9⅛ in. The bottom wall thickness is 30⅛ in., while that of the top wall is 8 in. A free area of 154 sq. ft. has been provided.

Condensate from the heaters used in connection with the hot-water heating system is ordinarily used for boiler feed purposes and when this is not sufficient to meet the demand make up may be secured through either one of two 3-in. lines, one of which ties in with the local city mains while the other connects with the motor test system in the works, this source providing a make-up at a temperature considerably higher than that secured from the city lines. This, as is also the condensate from the hot water heaters, is passed through a combined feed-water softener and heater of the open metering type before being fed to the steam generating units. The capacity of this heater for heating and softening the makeup is 7720 gal. per hour while for heating without softening the condensate is 44,480 gal. per hour.

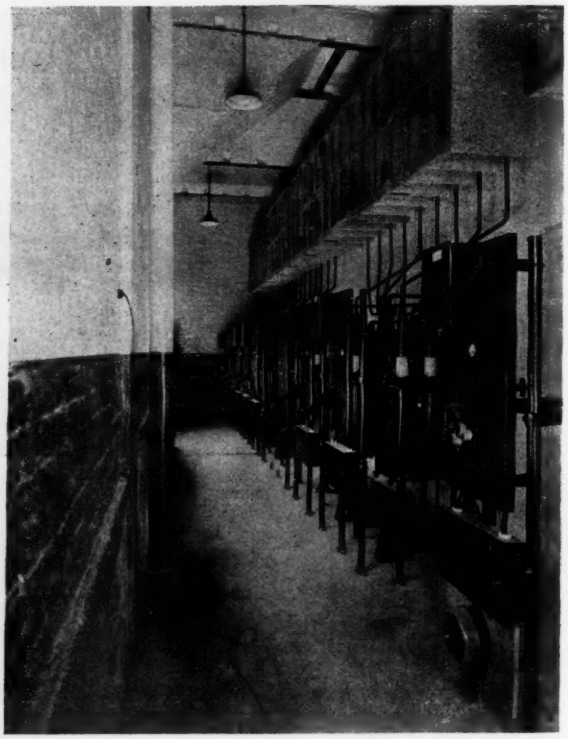


FIG. 7. SECTION OF HIGH-TENSION SWITCH ROOM

From the heater the water flows by gravity to the suctions of the boiler feed pumps through a 10-in. header carried along the boiler room wall of the pump room which, as indicated in the accompanying illustration, is located between the boiler house and the engine room. The present boiler feed equipment consists of three three-stage steam turbine driven units. Two of these have a capacity of 340 gal. of 212 deg. F. water per minute while the capacity of the other is 135 gal. of 212 deg. F. water per minute. The pumping head of each is 512 ft.

Discharge is directly into a main service header which has been fitted with indicating, recording and integrating flow meters; actual feed to the boilers is under the control of automatic regulators.

Engine Room Equipment

As previously stated, no electric generating equipment has been installed, the energy required being taken from the lines of the Detroit Edison Co. The apparatus in the engine room consists of four air compressors and four turbine-driven centrifugal pumps used in conjunction with the hot water heating system.

Three of the air compressors are of the cross compound, two-stage, engine-driven type, each with dimensions of 18 and 32 by 32 and 19 by 36 in. and with capacity ratings of 3340 cu. ft. of free air per minute at 100 r.p.m. and 3000 cu. ft. of actual air delivery at 90 per cent volumetric efficiency. The air is delivered at 110 lb. per sq. in.

The other compressor, which is also steam driven, is a 15 and 29 by 16 and 26 by 20-in. unit and is rated at 1955 cu. ft. of free air per minute at 160 r.p.m. and 1720 cu. ft. of actual air delivery at 88 per cent volumetric efficiency; the air pressure available ranges from 80 to 110 lb. per sq. in.

Below the floor of the engine room is an aftercooler of the horizontal multi-pass nested type with a cooling surface of 2000 sq. ft.

Each of the hot water circulating pumps installed in the engine room (shown in the foreground, Fig. 1) is a 14-in. unit of the three-impeller turbo-volute centrifugal type with a capacity of 5000 gal. of water per minute against a head of 94 ft. when working at a speed of 2150 r.p.m. Curtiss type steam turbines, direct connected, are used for their operation.

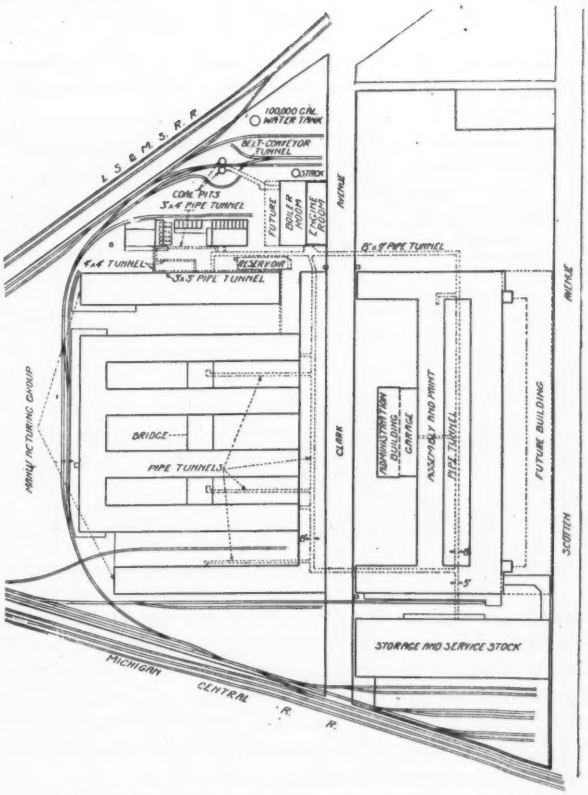


FIG. 8. LOCATION MAP, CLARK AVE. CADILLAC WORKS

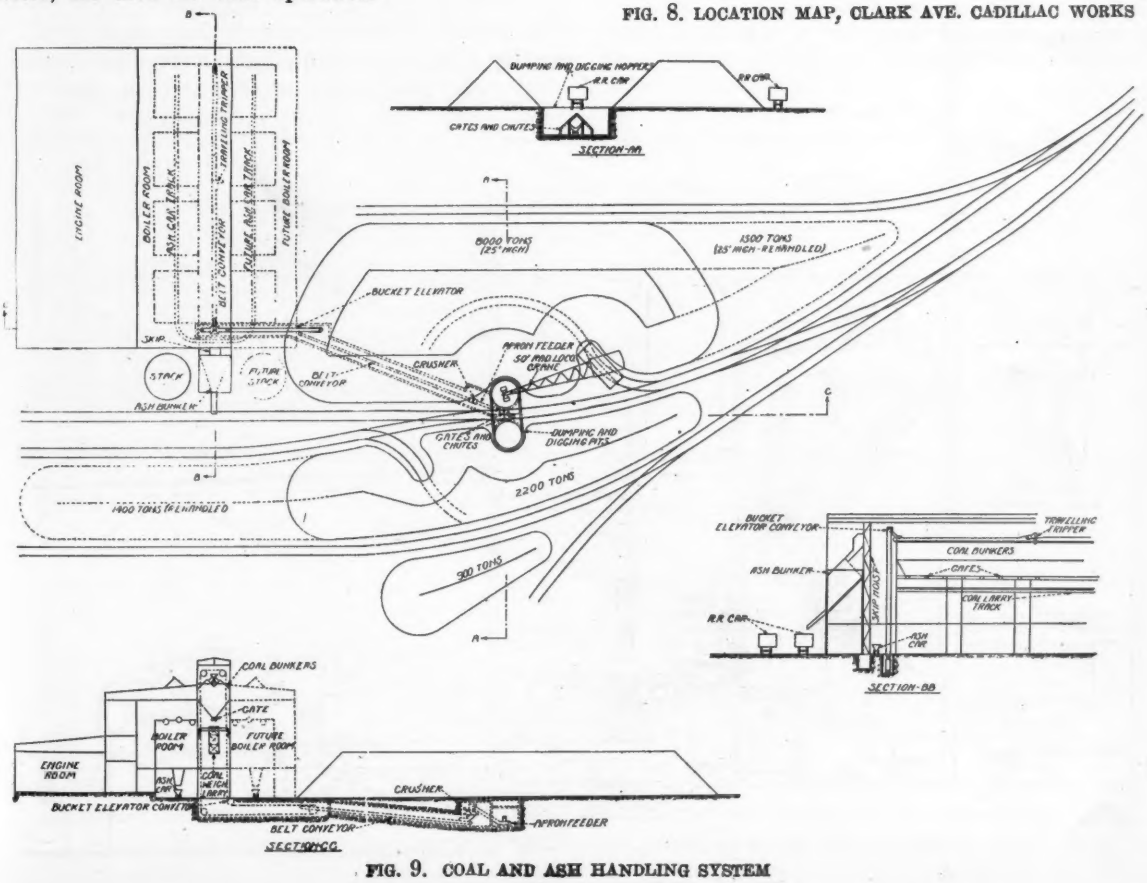


FIG. 9. COAL AND ASH HANDLING SYSTEM

The Steam Distribution System

Steam is taken from the boilers through 7-in. leads tying in with a 14-in. header carried along the rear of these units and so valved as to allow the cutting out of any battery section should operating conditions or emergency so require. Twelve-inch cross-overs at each end connect with a second header 10 in. in diameter located below the floor of the engine room, the function of this line being to serve the air compressors and pumps. For the former, 6-in. leads have been provided while for the pumps an auxiliary 5-in. loop with 2½-in. branches for each unit is installed.

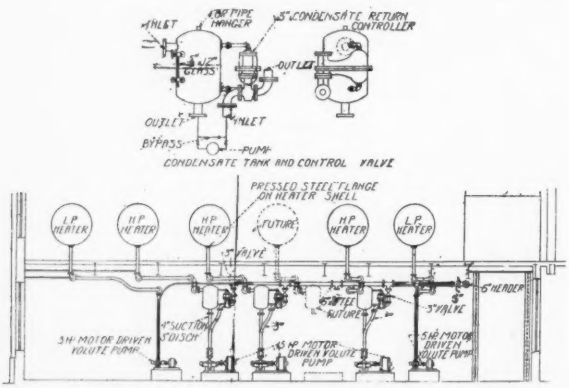


FIG. 11. HEATER CONDENSATE PUMP ARRANGEMENT

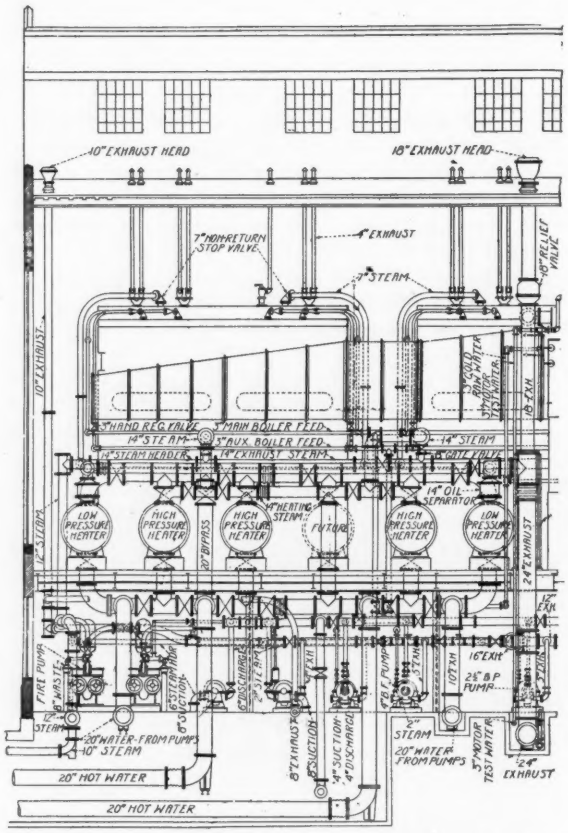


FIG. 10. SECTION THROUGH PLANT SHOWING REAR OF BOILERS, HOT WATER HEATERS AND PORTION OF PUMPING EQUIPMENT

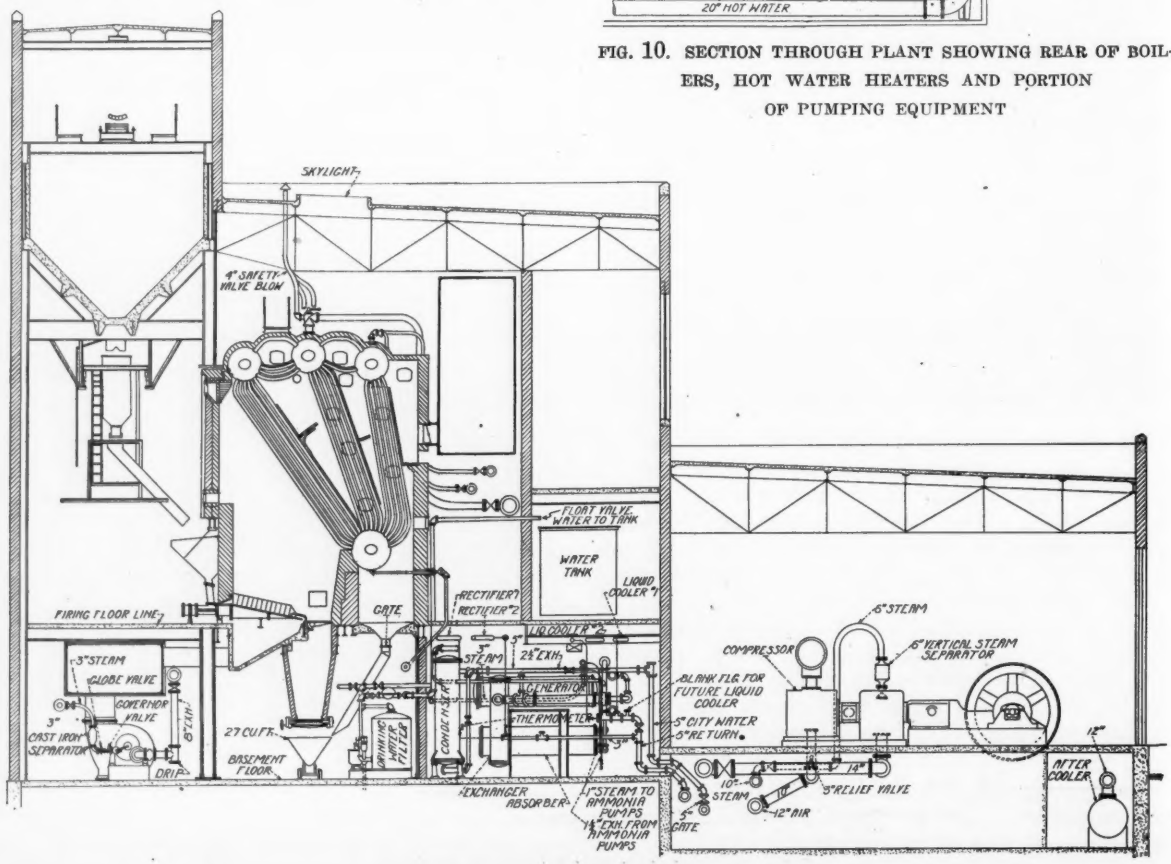


FIG. 12. SECTION THROUGH POWER HOUSE

A 6-in. auxiliary header is used to supply steam to the auxiliaries such as the forced-draft blower turbines and the various pumps.

Each of the large air compressor engines located in the engine room exhausts through 14-in. leads connecting with a main header made up of 16, 12 and 10-in. sections, the 10-in. sections being provided primarily to serve the hot water pump turbines (which are tied with 6-in. leads) and some of the minor auxiliaries. Forced draft turbines and pumps have separate exhaust headers (the former 8 in. and the latter 10 in.) all of which, however, through the medium of the necessary control valves and corrugated expansion joints, are tied in with the boiler feed water heater and a 24-in. main exhaust riser fitted with an 18-in. atmospheric relief valve for the disposition of surplus steam.

Heating the Works

To HEAT efficiently an extensive group of buildings such as comprise the Cadillac works is a problem requiring considerable engineering ability for its proper solution and after a thorough and careful study of local conditions, facilities and requirements the engineers engaged on this project decided in favor of a hot-water system. The scheme employed is somewhat unusual.

From the pumps in the engine room, the water used as the heat circulating medium is forced through closed heaters of which at present five are installed, arranged and connected in the manner shown diagrammatically in Fig. 10. The water is taken from the heating system through 20-in. lines branched with 16-in. leads and forced through the heaters at a pressure of 60 lb. gage. Either high-pressure or exhaust steam can be employed for heating the water, although the design and construction of the individual units does not allow their indiscriminate use under all conditions of pressure. Accordingly three high-pressure heaters each with a heating surface of 3030 sq. ft. and a capacity of 10,000 gal. per minute at temperatures of from 235 to 260 deg. F. with steam at 85 lb. gage, and two low-pressure units with 3769 sq. ft. of heating surface and capable of heating the same amount of water to temperatures ranging from

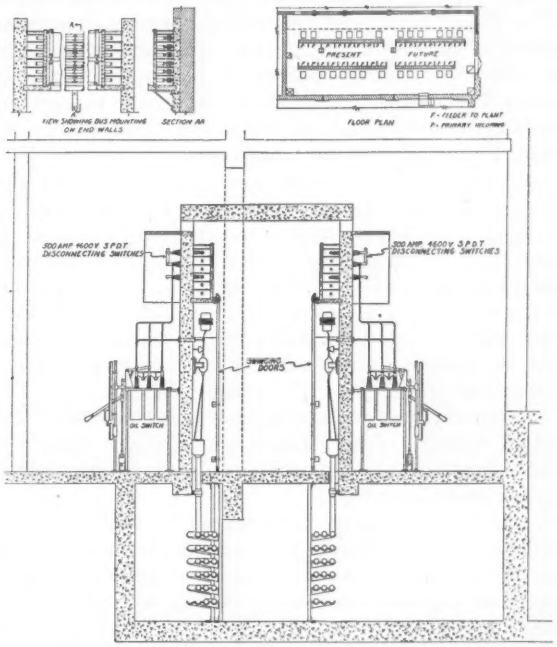


FIG. 14. SECTION THROUGH BUS STRUCTURE

200 to 205 deg. F. with steam at 3 lb. gage, are installed. Each of the high-pressure steam heaters has a diameter of 72 in. and a length of 12 ft. 9 in., while the exhaust steam units have an over all length of 12 ft. 6 in., with a diameter the same as that of the others.

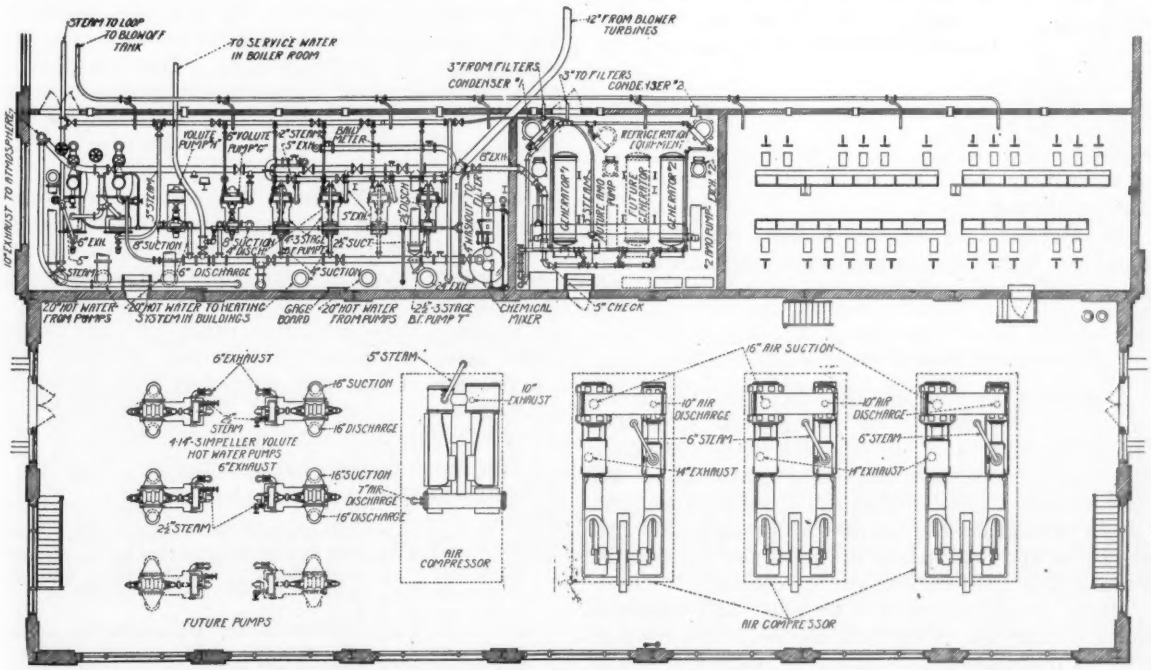


FIG. 13. POWER HOUSE ARRANGEMENT PLAN, ENGINE, PUMP, REFRIGERATOR AND SWITCH ROOMS

The low-pressure or exhaust heaters receive steam through a 14-in. line while the high-pressure units receive steam through two thermostatically controlled reducing valves. Water resulting from the condensation of the steam within the heaters is, in the case of each of the low-pressure units, allowed to gravitate to the suction of a 75-gal.-per-minute centrifugal pump direct-connected to and driven by a 5-hp. induction motor. For the others, the high-pressure units, however, a somewhat different scheme was of necessity employed. Condensate tanks are connected in the condensate discharge line between the heater and the pumps shown in Fig. 11, with a control valve in the discharge from the pumps, this serving as a controller to maintain a water seal against the higher steam pressure. The arrangement is such as to result in the opening or closing of the pump discharge line valve with a rise or fall of the water of condensation in the condensate line above or below a fixed level; thus, while the pump motor is maintained in continuous operation, the condensate is removed only as required, thereby preventing the escape of live steam.

Single-stage centrifugal pumps with capacities of 275 gal. of condensate per minute and direct connected to 15-hp. induction motors are used in conjunction with the high-pressure heaters.

The heating system is arranged so that it can be operated as two separate and independent systems, one taking care of the assembly and car storage and service buildings and any additional building which in the future may be erected on that side of Clark Ave., and the other the manufacturing buildings, paint and oil storage and any future structure built on the opposite side of the street. This provision was made so as to reduce to a minimum the possibility of poor distribution of the circulating water among the various radiators, and so that in case of accident only one-half the plant would be affected.

To each of the heating systems there will be ultimately connected 300,000 sq. ft. of cast-iron wall-type radiation. The installed radiation is at present as follows:

Building	Radiation
Paint and oil storage	400 sq. ft.
Assembly	87,600 sq. ft.
Car st. and service	23,000 sq. ft.
Manufacturing group	160,900 sq. ft.

The systems have been so designed and are so arranged that with a minimum outside temperature of —20 deg. F. water can be delivered to the radiators at 260 deg. F.

Electricity Supply and Its Distribution

Electric energy is purchased from the Detroit Edison Co. and delivered to the power house at 4600 v., through the medium of six three-conductor 450,000-circular mil., 7500-v. insulated paper and lead covered cables, in underground conduit and distributed to 16 substations throughout the works. At present, only such substations are constructed, equipped and in operation as required by the buildings already erected.

High voltage power is distributed and controlled from a primary switching room, specially built for flexibility of distribution and safety of operation, located in the power house as shown in Figs. 7 and 13. Two 8-in. reinforced concrete walls are built with concealed conduits for secondary wiring, porcelain tubes for primary copper to pass through and inserts for supporting barriers, instrument transformers, busses, disconnecting switches and the pipe framework for supporting the oil switches as shown in Figs. 7 and 14. The pot head and instrument transformers for each circuit are concealed in a gypsum compartment with a transite board door. The busses are concealed in transite lumber compartments and the disconnecting switches are separated with gypsum barriers with a double glass front door opening across each circuit. From the pot head to the oil switch to the disconnecting switch ¾-in. round copper is used and insulated with 10 layers of sheet cambric and one layer of ¾-in. varnished cambric tape lapped one-half. Each bus consists of two 2 by ¼-in. copper bars.

As may be seen by referring to the single line diagram, Fig. 15, five of the six supply circuits tie in with and feed individual main busses while the remaining circuit is used only for the operation of an auxiliary bus which extends the full length of the main busses. Thus, should the necessity of cutting out any main bus arise or the supply to such a bus fail, interruption to

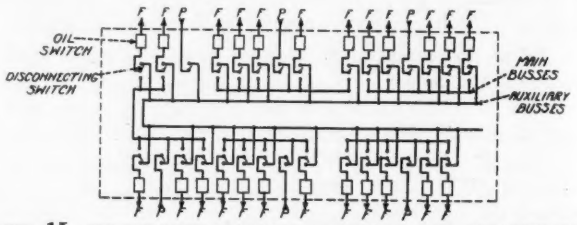


FIG. 15. SINGLE-LINE DIAGRAM OF SUPPLY, BUS AND FEEDER CONNECTIONS

operation can be readily prevented by throwing the load onto the auxiliary bus. This is accomplished by means of the double-pole disconnect switches.

Ultimately 16 substations will be served, distribution will be underground and a general scheme employed as indicated in Fig. 16. Substation 1, that located in the power house for local service, is equipped with one 50-kv.a., 4600-230-115-v. single-phase transformer for lighting and a bank of three 75-kv.a., 4600-230-v. power transformers, the former being protected on the primary side by two 300-amp. disconnect switches and two 25-amp. expulsion fuses, and the latter by three 300-amp. disconnect switches and a 300-amp., 7500-v. oil switch. The 230-v. side of the power transformer bank serves through the medium of a distribution bus and 300-amp., 7500-v. oil switches, three conductor paper and lead covered cables being employed; for house and auxiliary pump service, each of the cable conductors is of 500,000 circular mils while for the coal and ash handling motor circuits 200,000 circular mil conductors are used.

The remaining substation equipment is or will be according to present plans as follows:

Station No.	Lighting Transformers	Power Transformers
2	1—333 Kv.a. 4600-230-115 v.	3—333 Kv.a. 4600-230 v.
3	1—333 Kv.a. 4600-230-115 v.	3—500 Kv.a. 4600-230 v.
4	1—333 Kv.a. 4600-230-115 v.	
5	1—100 Kv.a. 4600-230-115 v.	
6	2—100 Kv.a. 4600-230-115 v.	Same used for power
7	1—333 Kv.a. 4600-230-115 v.	
8	1—333 Kv.a. 4600-230-115 v.	
9	1—333 Kv.a. 4600-230-115 v.	3—500 Kv.a. 4600-230 v.

10	1—333 Kv.a. 4600-230-115 v.	3—500 Kv.a. 4600-230 v.
11	3—100 Kv.a. 4600-230-115 v.	3—333 Kv.a. 4600-230 v.
12	1—333 Kv.a. 4600-230-115 v.	
13	1—250 Kv.a. 4600-230-115 v.	
14		3—100 Kv.a. 4600-230 v.
15	1— 75 Kv.a. 4600-230-115 v.	3— 50 Kv.a. 4600-230 v.
16	3—100 Kv.a. 4600-230-115 v.	6—333 Kv.a. 4600-230 v.

The total (ultimately) installed transformer capacity is 14,500 kv.a. of which 10,600 kv.a. is for power and the remainder for lighting.

Miscellaneous Equipment

All water used for drinking purposes is filtered and cooled to temperatures of from 45 to 50 deg. F., two 35-gal.-per-minute filters and two 35-ton absorption type refrigeration units having been installed for that purpose. One of the refrigeration units is shown in Fig. 6. The pumping equipment provided for this service comprises three twin volute centrifugal 50-gal.-per-minute units operating at a speed of 1735 r.p.m. and driven by and direct-connected to 7½-hp., three-phase motors of the induction type.

For general house service the following pumps have been provided: One 6-in. turbo volute centrifugal unit rated at 1200 gal. per minute, working head 175 ft., speed 3010 r.p.m., direct-connected to a Curtis type steam turbine; and one 1500 gal. per minute, 175-ft. head, 1750 r.p.m. single-stage, double-suction centrifugal pump driven through direct connection by a 100-hp., three-phase induction motor.

Fire Protection

In spite of the fact that upon completion of the Cadillac works the structure will be practically fire-proof throughout, ample means have been provided for the fighting of any fire which may occur. Three sources of water supply are normally available; the city mains, a 100,000-gal. steel tank elevated 120 ft. from the ground, and two 20 by 12 by 16-in. 1500-gal.-per-minute steam-driven Underwriters fire pumps held ready at all times for instant service.

Each building is provided with an extensive sprinkler system.

Utilities Distribution

Practically all air, water, and steam lines are carried through an extensive underground tunnel system which connects either directly or through branches to each of the buildings comprising the works. From a 20-ft. wide outlet in the basement of the engine room, three branches of the system emanate each with sectional

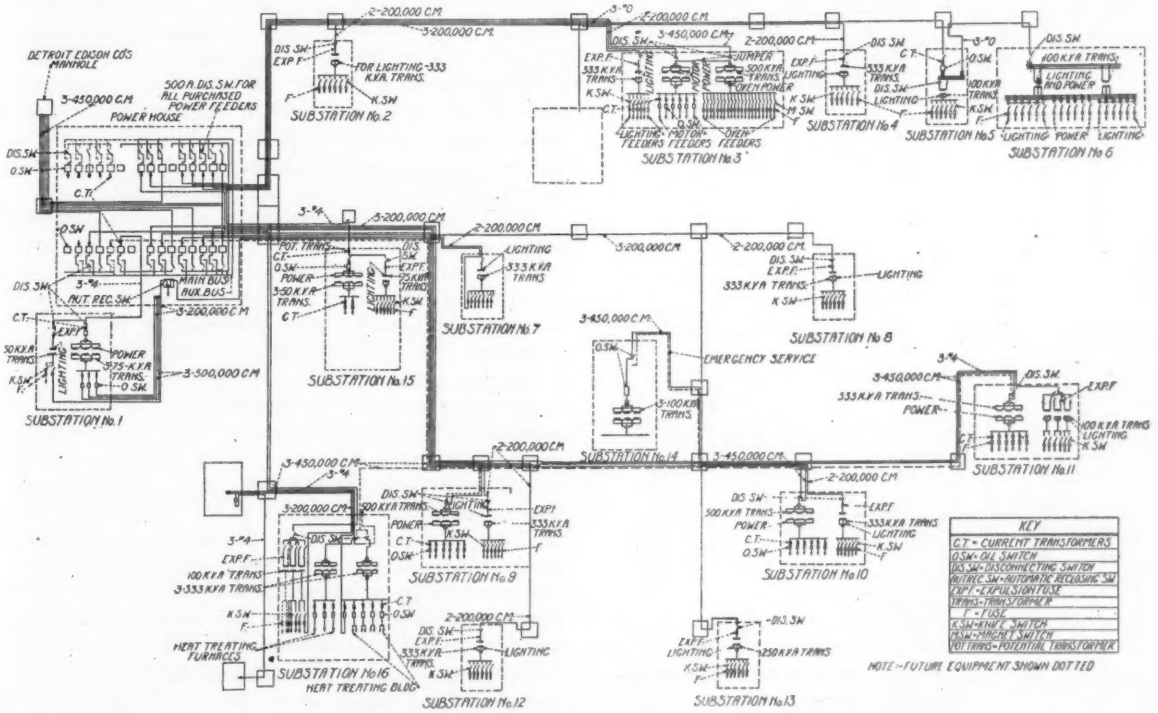


FIG. 16. ELECTRIC TRANSMISSION SYSTEM—SINGLE-LINE DIAGRAM

dimensions of 8 by 9 ft. One of these as shown in Fig. 8 serves the heat treatment, the salvage and the paint and oil buildings; the second, the various machine buildings, and by means of an 8 by 8-ft. tie-in with the third in the form of a loop the assembly and paint, the car storage and service and the administration buildings.

The hot water lines leaving the power house are each 20 in. in diameter, but are reduced in size as their lengths increase. That serving the machine buildings consists of 16 and 10-in. sections with 12 and 10-in. branch feeders carried into the structures, and main risers of 12, 10 and 8 in. respectively. Sixteen, 14 and 12-in. sections feed the assembly and paint shops, the car storage and service shops and the administration building.

Expansion joints are placed approximately every 112

ft. with anchors midway between providing ample means for caring for the expansion and contraction of the pipe lines and insuring their security.

A plan and elevation of a typical section (assembly and paint building) is shown in Fig. 17. On one side are carried the 16-in. hot water heating supply, the 8-in. service water, the 6-in. steam supply and the 2-in. drinking water lines, while on the opposite side are carried the 16-in. hot water heating return, an 8-in. air, a 3-in. steam return and a 1½-in. drinking water line. An offset in the tunnel provides an outlet for the various risers serving the building.

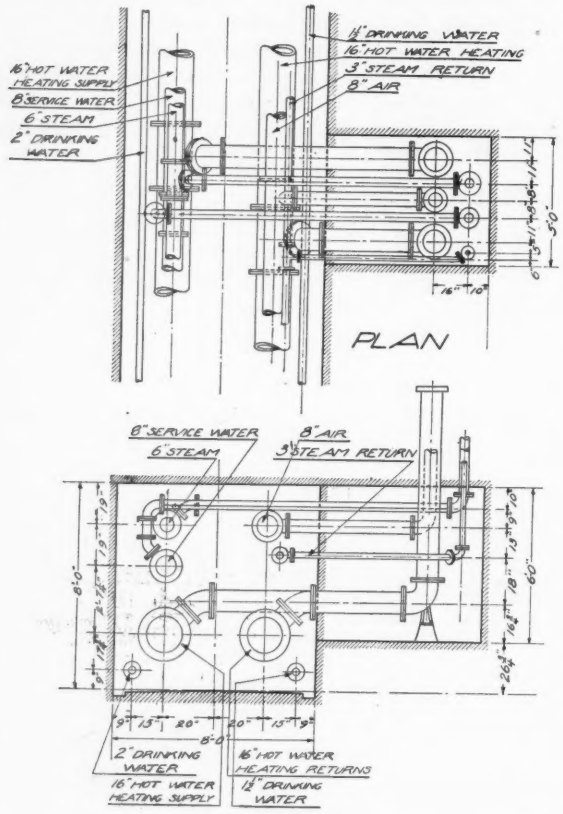


FIG. 17. TYPICAL TUNNEL SECTION SHOWING RISER CONNECTIONS

Conductors used in the transmission of electric energy are carried in fibre conduit embedded in concrete and fitted with Harrington socket joints.

Lighting Layout

THE GENERAL plant lighting scheme consists of 200-w., 115-v. bowl-enameled lamps equipped with R.L.M. dome-type reflectors. Each unit is spaced on 11-ft. centers at a height of 11 ft. above the floor.

Conclusion

IN CONNECTION with the design of the Cadillac plant, the entire present and ultimate development was the subject of an exhaustive study, the result of which was to determine the size, arrangement, height, location with respect to each other, character of construction, etc., of the buildings to give the greatest efficiency in the manufacturing processes and of the moving of parts through buildings for the assembly of the finished car.

This is perhaps the largest factory built at one time for the manufacture of automobiles and is by many considered the best of its kind in every particular. All buildings are designed to be ultimately six floors high, although at present (except for part of the manufacturing group which is three floors high) only four floors have been built.

The site contains 46 acres and the buildings as now built provide 1,900,000 sq. ft. of floor space. Eventually the floor space will be 3,900,000 sq. ft., of which 16,000 will be for office space and 12,000 for garage.

The power plant also has been built with the same end in view, namely, future expansion to the ultimate, and is so arranged as to be able to take care of extensions with the minimum of expense. The boiler room now has six boilers with room in the present room for two more or a total of eight, and is so arranged that an additional eight can be located in a new part of the building with the firing aisle between the two rows of boilers. The bunker overhead and all coal handling apparatus is large enough and so arranged as to take care of the additional load, if required. The engine room, pump room and space for heaters for heating system are also arranged so that any additional apparatus may be logically located in the new building.

The piping systems for steam, air, water, hot water, drinking water, etc., in the tunnels and buildings are all arranged with blanked tees wherever there is likely to be a future connection required. What is said of the tunnel mains is also true of the building piping, which is arranged for six floors as the future development.

In connection with the heating system, this is so arranged that there is no necessity on the part of any employe in the factory to operate any radiator valves; in fact these valves are provided for shut-off purposes in case of a break in the radiator, rather than to regulate the temperature. Regulation of the temperature in the buildings is taken care of by having the water leave the power house at a predetermined temperature, which is varied inversely as the outside temperature and the temperature of the hot water is maintained at the desired point by a special thermostatically operated steam valve.

As in the case of the plant of the St. Louis Manufacturing Co. Division of the General Motors Corp., description of which appeared in the Sept 1, 1920, issue of this publication, all engineering and construction work in connection with the Clark Ave. Cadillac Works was done by the Du Pont Engineering Co. of Wilmington, Del.

U. S. CIVIL SERVICE COMMISSION announces an examination (receipt of applications to close Feb. 1, 1921) for Fuel Engineer ($2500 to $4200), Assistant Fuel Engineer ($1800 to $2500) and Junior Fuel Engineer ($1620 to $1800) to fill vacancies in the Bureau of Mines, Department of the Interior, for duty at Pittsburgh, Pa., at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries. Appointees at annual compensation of $2500 or less, whose services are satisfactory, may be allowed the increase granted by Congress of $20 a month. Apply for Form 2118, stating examination title.

Valves for Inconvenient Locations

Methods of Reaching and Operating in Power Plants. By Charles L. Hubbard

THE multiplication and location of valves in the modern power or heating plant of large size brings up a point which is sometimes lost sight of by the designing engineer or contractor installing the work.

This relates to their accessibility, which oftentimes is a matter of the greatest importance. Emergency shutoff valves in high and low-pressure steam mains may be used only at infrequent intervals, but conditions require that they should be easily reached for quick action in case of necessity. On the other hand, there are valves which are used only for cutting out sections of the piping when making repairs or installing new equipment where quick action or convenience is of minor importance.

Between these extremes is a great variety of conditions embracing valves of all kinds requiring greater or lesser degrees of accessibility according to their use.

It is proposed in the present article to discuss briefly some of the points to be considered in the construction of ladders and platforms for reaching valves in various locations and also to describe some of the various types of valves upon the market designed especially for awkward positions, and others which may be operated in different ways from a distance.

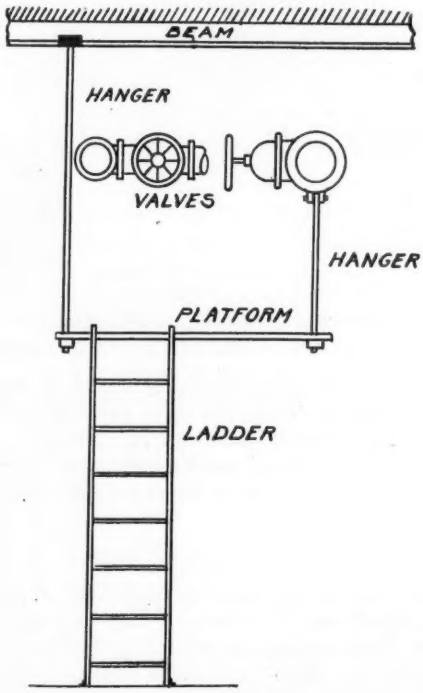


FIG. 1. LADDER AND PLATFORM FOR CONVENIENCE IN OPERATING VALVES

Ladders and Platforms

For overhead valves which are used only at infrequent intervals nothing is better than a substantial wooden ladder with steel spikes at the bottom to prevent slipping. This is easily carried from place to place and may be hung out of the way when not in use.

For valves which are more frequently used, and especially those coming near walls or columns, a permanent iron ladder should be provided. This may be constructed either of wrought-iron pipe and fittings or of standard forms of steel such as are commonly used in light building construction. Ladders of this kind should be anchor-bolted to the adjacent wall or clamped to nearby pipes or columns as may be most convenient.

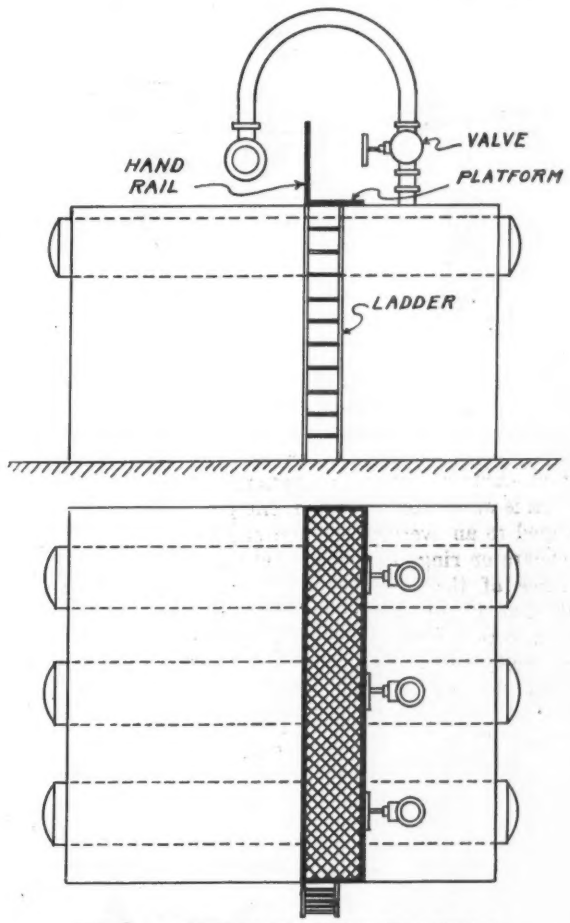


FIG. 2. LADDER TO PLATFORM OVER BOILER

When the valve is large and requires both hands for manipulation, a footing or small platform a short distance from the ladder should be provided for bracing the feet when using the hands. In cases of this kind the arrangement should always be such that the engineer may easily maintain his balance and have a firm footing while having free use of both hands.

The next step from this is a platform giving access to one or more valves, with a metal ladder leading to them.

This applies more especially to groups of valves, such as the cut-out and bypass valves for a pressure

reducing valve. An illustration of this kind is shown in elevation in Fig. 1.

In cases of this kind, the platform is usually constructed with an angle-iron frame, or border, filled in with a heavy wire netting having a sufficiently fine mesh to give a substantial footing. Wire for this purpose should be from 3/16 to ¼ in. in diameter, depending upon the size of the platform and the distance between supports. While a wooden flooring may be used in some cases, it is likely to become slippery with oil and also looks out of place where all other construction

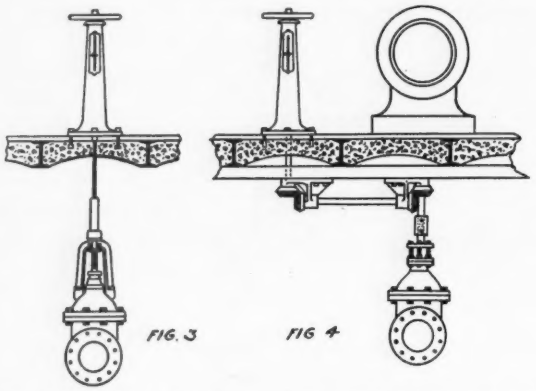
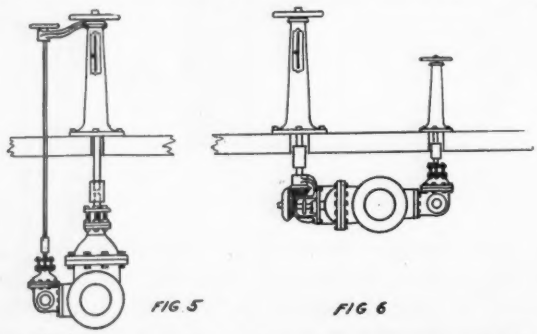


FIG. 3. VALVE STEM EXTENDED FROM BASEMENT TO ENGINE ROOM FLOOR
FIG. 4. OFFSET ARRANGEMENT OF VALVE AND STAND

is of iron or masonry. The method of support will depend largely upon the location. That in the illustration is hung from overhead, one pair of hangers being clamped to an overhead I-beam and the others fastened to collars or rings around one of the pipe mains. The distance of the platform below the valves should be such that a man of ordinary height may easily reach the hand-wheels when standing upright. This, at the same time, will make it possible for him to pass under any of the lines of piping without stooping uncomfortably low. When possible, the arrangement should be such that the engineer can step directly from the ladder to the platform without passing under a pipe.



FIGS. 5 AND 6. TYPICAL ARRANGEMENTS OF EXTENDED VALVE STEMS ON BYPASS VALVES

A typical layout of ladder and platform for reaching the cut-out valves over a battery of boilers is shown in plan and elevation in Fig. 2. The ladder, in this case, is given a slight incline from the vertical and is provided with a hand rail. The platform rests on top of the boilers in front of the valves as indicated. These are simple illustrations of what may be done in this line and are given simply as suggestions in working out similar arrangements for more or less complicated conditions along this general line.

The Extension of Valve Stems

Frequently it is much more satisfactory to extend the valve stem to an accessible location than to provide ladders or other means for reaching a valve of ordinary design. A typical scheme of this kind frequently found in power house work is shown in Fig. 3 and is extensively used when the main supply and exhaust piping are carried in a space beneath the main engine room floor. These devices are made to be attached to any standard form of valve by omitting the usual hand wheel. When, for any reason, the valve-stand cannot be placed directly above the center line of the valve below, it may be offset, as shown in Fig. 4, by the use of a horizontal shaft and beveled gears. Typical arrangements with bypass valves, and cases where the main valve must be placed upon its side, with the spindle in a horizontal position, are shown in Figs. 5 and 6. The first of these is similar to that shown in Fig. 3,

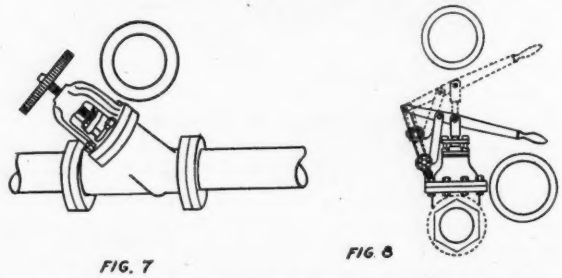


FIG. 7. SPECIAL VALVE MAKES PROPER LOCATION POSSIBLE
FIG. 8. LEVER VALVE FREQUENTLY AID TO ACCESSIBILITY

with the addition of a vertical extension to the bypass valve. In Fig. 6, where the main valve is placed upon the side, the vertical extension is connected with the valve stem by means of gearing, while the arrangement of the bypass is such that a direct connection is possible, as in Fig. 5.

Special Forms of Valves

Sometimes an awkward or inconvenient position of a valve wheel may be avoided by using a special form of valve. Such a case is shown in Fig. 7, where a Y-valve is perfectly accessible in a place where the usual type of gate or globe valve might be very difficult to manipulate. This is simply one of many similar cases which might occur, and is suggested as a "way out" under such conditions.

Figure 8 shows how a lever valve may sometimes be substituted for the usual type where it must be opened and closed at frequent intervals. Figure 9 shows a special valve operated by worm gearing and, by varying the length of the operating rod, may be made to fit into many awkward positions and simplify the manipulation of valves in a considerable variety of cases.

Valves Employing Gearing

While the use of gearing has been touched upon

in some of the cases already described, there is such a wide application of this principle that it may be well to show other conditions where this arrangement may be utilized to advantage.

In Fig. 10 is shown an awkward case where it would be difficult to use a straight gate valve. There is room neither in a vertical nor horizontal direction for the stem, and it is not desirable to place a gate valve with the stem extending downward because if not fully opened the projecting gate forms a dam or obstruction to the

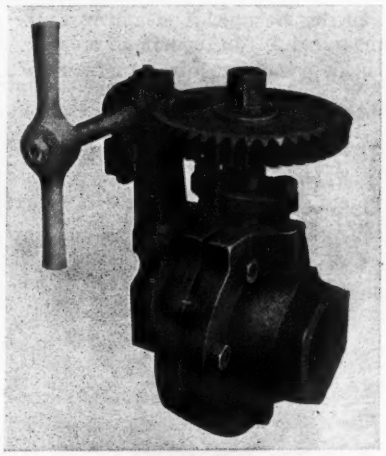


FIG. 9. VALVE STEM FITTED WITH WORM GEAR

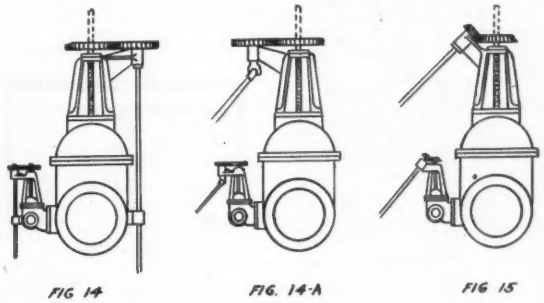
flow of condensation along the bottom of the pipe which may cause severe water-hammer.

By using a geared valve and extending the stem in either direction horizontally, as most convenient, it is easily reached for manipulation, and the bonnet of the valve is also accessible for removal when necessary.

Figure 11 illustrates a case where the main runs too close to a wall to allow space for the hand wheel, and where an adjacent line of piping prevents turning the valve stem at an angle; also, if placed on its side, the wheel would come in contact with the floor, or at least be in an awkward position to reach. By using a gear and pinion the wheel is offset so as to clear the wall, and at the same time makes it possible to use one of smaller diameter in case that should be an advantage in any particular instance.

Figure 12 shows a condition where a valve like Fig. 10 may be used, but in a different position; in this case the hand wheel is easily reached for manipulation and the bonnet for removal. Another condition adapted to a case of this kind of valve is shown in Fig. 13 and requires no special explanation.

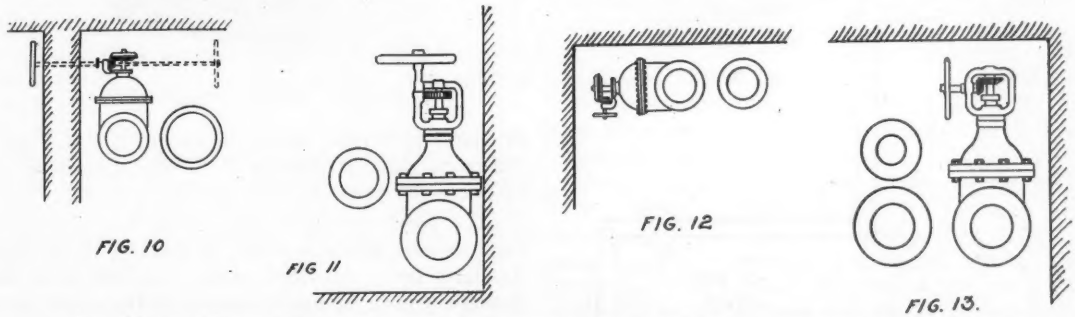
Geared valves with extension rods for inaccessible overhead positions are illustrated in Figs. 14, 14A and 15. The first of these relates to a large valve, with bypass, where the operating rods are brought vertically downward. In Fig. 15 they are carried from the valve at a fixed angle, adapted to the special requirements of the case in hand. The arrangement in Fig. 16 makes use of universal joints in the rods, which adapts them to any angle within a considerable range, which is often a matter of much convenience. All of the valves illustrated are of standard design, and special attention is called to their use in a number of typical cases merely as suggestions for overcoming difficult problems in power plant design and construction.



FIGS. 14, 14A AND 15. OVERHEAD VALVES OPERATED BY GEARED EXTENSION STEMS

Pneumatic Valves

These were designed originally for heating installations in connection with automatic control, but have a considerable field in any class of low-pressure work where the valves must be opened and closed frequently or are located a long way from the boiler room or in places difficult to reach conveniently. A typical valve of this kind, of large size, is shown in Fig. 16. It is of the globe type and is held open by the pressure acting upon the lower side of the disc assisted by a coil spring around the stem. The upper end of the stem rests on a plate supporting a rubber diaphragm which forms the bottom of an air chamber. The valve is closed and opened from any distant point by admitting or exhausting air pressure to or from the chamber above the diaphragm by means of a "three-way" cock located at any convenient point. If the valve must necessarily



FIGS. 10, 11, 12 AND 13. CASES WHERE GEARING MAKES CORRECT LOCATION OF VALUE POSSIBLE

be placed at a point very close to other piping, and especially where there is but little circulation of air over it, a valve employing a metal bellows in place of a rubber diaphragm should be used, as the latter is comparatively short-lived under these conditions. A section through a pressure chamber and metal bellows is shown in Fig. 17 and illustrates the general principle of this device. The air pressure is admitted to the space out-

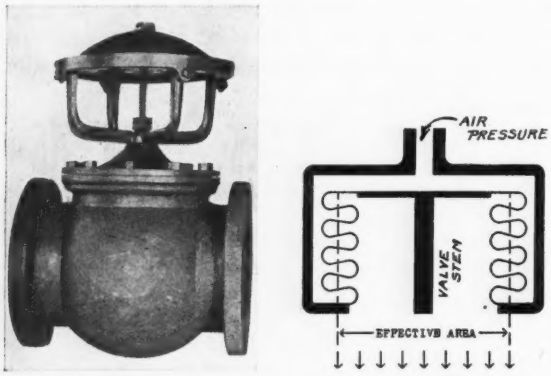


FIG. 16. EXTERIOR VIEW OF PNEUMATIC TYPE VALVE
FIG. 17. METAL BELLOWS USED ON PNEUMATIC VALVES

side the bellows, which acts as a piston having a diameter equal to that indicated by the arrows.

Pneumatic valves are very useful in connection with heating plants, especially for hot-blast heaters located some distance from the engine room, as with this arrangement it is possible for the engineer to turn on or shut off sections as needed by simply throwing small "three-way" air switches located at any convenient

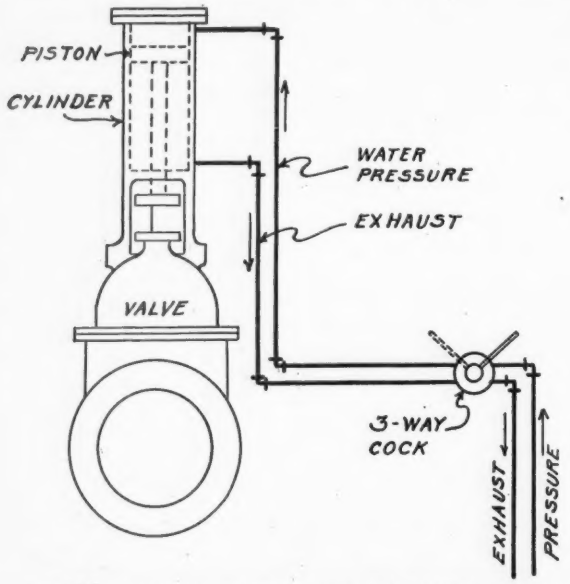


FIG. 18. VALVE OPERATED BY HYDRAULIC PRESSURE

point. Heating mains leading to different buildings, or sections of a plant, may be handled in the same manner by the use of the larger size valves of the general type shown in Fig. 16.

In fitting up a hot-blast heater with pneumatic valves it is usually customary to connect one of the sections for automatic control from the thermostat in the air duct and operate the remaining ones by hand through compressed air switches as just described. In arrangements of this kind, devices are usually mounted upon the board with the air switches for indicating the temperature in the main air-way leading from the fan. Pneumatic valves in heating mains leading to different buildings or departments of a plant are especially useful in case of sudden leaks or accidents when it is desired to shut off steam quickly. The air pressure for operating valves of this kind is furnished by a small automatic compressor driven by electricity, steam or water pressure, as most convenient in any particular case. About 15 lb. per sq. in. is usually required for work of this kind.

Valves Operated by Water Pressure

Any of the pneumatic valves described may be operated by water pressure, if for any reason that is more convenient; but in most cases, air pressure will

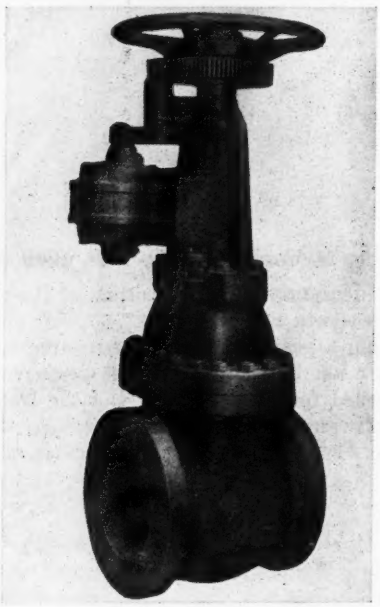


FIG. 19. MOTOR OPERATED VALVE

be found preferable owing to its quick action and the ability to exhaust directly with the atmosphere when relieving the pressure and opening a valve.

A typical hydraulic gate valve for either low or high-pressure steam is shown in Fig. 18. This is of the standard form, provided with a smooth stem sliding through a packing gland instead of the usual threaded stem and nut.

The upper end of the stem is attached to a piston enclosed and moving in a metal cylinder. Two pipes lead to the cylinder from a three-way cock, one connecting with either end. By throwing the lever of the cock in one direction, water pressure from the main is admitted to the upper end of the cylinder, while the pipe leading from the lower end is open for exhaust through the cock, as indicated by the arrows in Fig. 18. This action, it is evident, will close the valve. Throwing the lever in the opposite direction reverses the conditions and opens the valve. This device is especially

adapted to the operation of gate valves where a high lift and therefore considerable movement is required.

Electrically Operated Valves

A GATE VALVE of large size operated by an electric motor is illustrated in Fig. 19. The speed of the motor is reduced through a train of gears, and the arrangement is such that the current is cut off automatically at the instant the valve gate reaches an open or closed position. The motor and all connecting gears are enclosed in a casing not shown in the cut. As stated in the beginning, no new types of equipment have been considered, but familiarity with the different valves upon the market, designed especially for difficult or inaccessible locations, will be of considerable assistance to the engineer in certain cases when laying out new work or making changes or additions to a plant already installed.

Manila and Wire Rope

Materials Used, Various Methods of Twisting Fibers, Strength, Care and Use of Ropes. Prepared by the Engineering Section, National Safety Council

MANILA ROPE is extensively used in practically all industries for various purposes such as suspending scaffolds and staging, hoisting tackle, unloaders and power transmission. To understand how to use rope safely and how to secure from it the maximum of service, it is well to know how the rope is manufactured, and also something about the material from which it is made.

Manila hemp, from which the rope is made, is the dried fiber of the Abaca plant (wild banana), native to the Philippine Islands.

When the trees are about 3 yr. old, the leaves are stripped from the tree and the fiber separated from the pulp by drawing between a block and knife (usually bamboo sticks). These fibers are then spread out and dried in the sun and baled for shipment. The fibers vary in length from 6 to 12 ft. or more and are separated in grades based on their color, strength, fineness and length. There are many grades of manila rope, depending upon the quality of the fiber from which the ropes are made. There are also several grades of rope made from low-grade fiber, either pure or mixed, such as New Zealand, Sisal, Jute and Russian hemp. Rope made from the manila hemp is by far the best and is recommended where strength, durability and long service are desired.

Fiber Test

THE BUREAU of Standards has approved a chemical test for detecting non-manila fiber in rope. A sample 12 in. long is cut out of the rope coil for examination. This is separated into strands and the oil rinsed out with ether or alcohol. It is then immersed for 30 sec. in a bleaching powder solution acidified with acetic acid, rinsed in water, then in alcohol, and finally exposed to ammonia fumes. Manila fibers turn brown, all other fibers a cherry red.

Making the Rope

WHEN the bales of fiber (hemp) are received at the cordage factory the fiber is shaken out, combed and straightened by hand. During the preparation of the fiber for rope manufacture jets of oil are sprayed on the hemp to provide the necessary lubrication of fibers in the finished rope. The prepared fiber (sliver) is twisted into yarn by a spinning machine, the size and firmness of the yarn depending on the size of the sliver and the number of turns per foot; this twisted yarn is wound on large spools or bobbins from which it is twisted or formed into strands, and finally these strands are twisted into the finished rope.

The fibers are spun into yarn by twisting in a right hand direction. From 20 to 30 of these yarns, depending on the size of the rope, are then twisted together in the opposite direction, or left hand, into a strand. Three of these strands, for a three-strand, or four for a four-strand rope, are then twisted together in the right hand direction to form the finished rope. When the yarn is twisted into the strand it partly untwists each of the threads of yarn and when the strands are twisted into rope, this final twisting action partially untwists the strands but again tends to twist the threads. It is this principle that keeps the rope in its proper form.

Care of Rope

MODERATE STRAIN on a rope in which there is a kink will overstrain the fibers at the point of the bend, thus decreasing the strength of the rope. Every precaution should be taken to avoid kinking as this is one of the main causes of injury to manila rope. Kinking is more liable to occur when a rope is wet, due to shrinkage of the rope caused by the swelling of fibers and the consequent shortening of the lay resulting therefrom. To prevent kinks in new rope while uncoiling, lay the coil on the floor with inside end down; then reach down through the center of coil and uncoil from the inside of the coil, never from the outside.

Rope deteriorates very quickly if it becomes saturated with water and is not properly dried out. Whenever ropes have become wet and dirty they should be cleaned and hung up, or laid in a loose coil so that they may thoroughly dry.

Small ropes and tackles should be hung up, and large ropes coiled on gratings raised from the floor to insure circulation of air. Alternate wetting and drying causes more rapid deterioration than occurs where a rope is always wet. Ropes used in construction are constantly subjected to the wetting and drying process and as a result they deteriorate rapidly.

Rope should not be allowed to freeze after becoming wet, as frozen rope easily breaks. Frozen rope should not be piled against radiators, steam pipes, nor close to other sources of heat, which will tend to dry out the oil and thus destroy the life of the fiber.

All sharp bends of rope over an unyielding surface should be avoided, as these bends cause extreme tension of the outside fibers of the rope and the sharp corner may cut the fibers on inside of rope. Care should be

taken in making a rope fast to select, if possible, an object with a smooth round surface of sufficient diameter.

Rope should not be used in locations where exposed to acid. This is of special importance in suspending scaffolds from which men must work. Acids of all kinds will cause immediate damage and often the decay of the fibers, so that when the rope is put into service it is liable to break without warning at any point where acid has come in contact with it.

Rope dragged along the ground not only loses some of its substance, but also picks up grit which eventually will grind out the rope fibers. All unnecessary dragging of rope along ground, over rough surfaces, or across itself should be avoided.

Surface wear of the rope also occurs when the sheave holes in blocks are too small to permit sufficient clearance, and when the rope is out of proper alinement, thus causing the rope to chafe against the block. Internal wear (friction) of the fibers is always present to some extent in that part of the rope which is running over a sheave or pulley. The smaller the diameter of the sheave or pulley, the greater will be this friction and the greater the internal wear of the rope fibers. Eventually this chafing of the outside of the rope and the internal friction results in a breaking up of the fibers. The life of a rope is greatly prolonged by using blocks with sheaves of large diameter.

WEIGHTS AND BREAKING STRENGTHS OF MANILA ROPE

Approximate diameter in inches	Circumference in inches	Approximate weight of a 1,200-foot coil	Minimum breaking strength in pounds
6-thd. ¼	¾	24	700
9-thd. 5/16	1	35	1,200
12-thd. ⅜	1⅛	50	1,450
15-thd. 7/16	1¼	66	1,750
18-thd. ½	1⅜	78	2,100
21-thd. 9/16	1½	90	2,450
5/8	1¾	126	3,150
⅝	2	160	4,000
¾	2¼	198	4,900
13/16	2½	234	5,900
⅞	2¾	270	7,000
1	3	324	8,200
1 1/16	3¼	378	9,500
1⅛	3½	432	11,000
1¼	3¾	504	12,500
1 5/16	4	576	14,200
1⅜	4¼	648	16,000
1½	4½	720	17,500
1 9/16	4¾	810	19,500
1⅝	5	900	21,500
1¾	5½	1,080	25,500
2	6	1,296	30,000
2 1/16	6½	1,500	34,000
2¼	7	1,764	38,500
2½	7½	2,016	43,500
2⅝	8	2,304	49,000
2⅞	8½	2,580	55,000
3	9	2,916	61,000
3⅛	9½	3,240	67,000
3¼	10	3,600	73,000

Note: The values in this table are for 3-strand medium laid rope; the 4-strand rope is from 5 to 7 per cent heavier and of approximately the same strength. The approximate relative strength of fiber rope in per cent is: Manila, 100; New Zealand, 82; Sisal, 67.

During the process of rope manufacture the fibers are treated with oil for the purpose of internal lubrication and as a preservative. The quantity of lubricant used should constitute from 8 to 12 per cent of the weight of the rope, and no substance should be added for the purpose of loading or weighting the rope.

For certain purposes, as in the construction of fishermen's nets and for standing rigging on ships, the rope is usually tarred to protect it from the water; that used in hoisting apparatus, however, should not be tarred because of the tendency of dirt and other particles to stick to the rope, which in time will grind it out. A preservative which will be absorbed into the rope and not leave a sticky coating is preferable.

Much depends on employing the best grade of rope for general hoisting purposes as well as for suspending platforms and scaffolds from which men must work. Such ropes are often exposed to the weather for considerable periods and are used frequently when there is doubt as to their fitness for service. They may look sound and strong on the outside and yet not be in good condition on the inside. To guard against accidents from the use of ropes in doubtful conditions, it is therefore important that a thorough inspection of the rope be made from time to time. Abrasion and broken fibers on the exterior of the rope are easily detected. The condition of the inner fibers, however, can only be determined by a close inspection. That section of the rope under suspicion should be opened up to determine the condition and color of the fibers. It may even be advisable to separate one piece of yarn and test it by breaking by hand. In general, any rope which has lost its "stretch" or in which the fibers have lost their brightness and luster should be viewed with suspicion. It is best to replace the rope rather than use one of doubtful strength.

New rope should be examined before being put into use to see that no steel wire strands have been placed in it by the manufacturer. This is important if the rope is to be used by electric linemen, or in locations where it may come into contact with electric light or power lines. In such a case, a steel strand would expose the workmen to the danger of electric shock.

The attached table of weights and breaking strengths for various sizes of manila rope is taken from U. S. Navy Department specifications (also known as Bureau of Standards specifications).

The loads put on rope should not exceed those given in the table if economical wear is to be expected. Indications of excessive loading are twists coming out of the rope, or the strands slipping out of their proper position. A certain amount of twist comes out of the rope in using it the first day or two, but after that the rope should remain substantially the same. If this is not the case, the load is too great for the strength of the rope.

It should be remembered that hoisting rope is ordered by the circumference, and transmission rope by the diameter sizes.

It is always advisable to test rope used in tackle from time to time. If rope blocks are laid away for a time and there is a possibility that the rope may have become injured by acid, dry-rot, or other cause, they may be tested by three or four men swinging on them. Test them with at least three times the load they will be called on to carry in service.

Wire Rope

Wire rope has almost entirely superseded manila rope and chain for purposes of hauling and hoisting. Some advantages of wire rope over manila rope are: (1) greater strength for the same diameter and weight; (2) equal strength whether wet or dry; (3) a constant length under all weather conditions; (4) greater uniformity in strength throughout its length; (5) larger variety in

types of construction for different uses; (6) lower cost per unit of strength; (7) greater durability. Some advantages in the use of manila rope are: (1) greater softness for hand work; (2) greater flexibility; (3) greater range of elasticity.

In the development of wire rope several methods of construction have been used, but experience has resulted in the discarding of many of these and standardization of others. The rope is made of wires, either twisted together or laid parallel to one another. The latter type of rope is employed only on large suspension bridges, whereas ropes for practically all industrial purposes are of the twisted variety.

The twisted, usually called stranded wire rope includes (a) flat rope, consisting of a number of wire strands laid side by side and sewed together with annealed wire; and (b) round rope consisting of several strands twisted around a core (usually of hemp).

The strand is the unit in rope construction. The number of wires used in a strand is usually 4, 7, 12, 19, 37, 61, or 91. Strands made of a large number of small wires are more flexible than those made of few large wires. Of the different types those most generally used are:

(a) Common (one-size wire) construction consisting of 19 wires all of one size;

(b) Warrington (three-size wire) construction consisting of seven wires of uniform size, surrounded by 12 wires which are alternately large and small; this construction increases the metallic area and the strength by approximately 10 per cent; for general hoisting purposes this has proved to be the best construction and has been adopted by the manufacturers;

(c) Seale construction, in which the center wire is large, the next layer of nine wires small, and the outer layer of nine wires large; this type construction of rope is somewhat stiffer than the other two constructions and is suitable only for a limited number of applications.

The core of the rope is generally hemp saturated with a lubricant. Wire strands are twisted around the hemp core either to the right or left, and the resulting rope is therefore designated as right-lay or left-lay. Six strands are usually used in rope construction, though for special service there may be fewer or more strands. The twist may be long or short, according to requirements. Shorter twist rope is more flexible, longer twist is more rigid. The hemp core provides little additional strength, but acts as a cushion to preserve the shape of the rope and also helps to lubricate the inside wires. Cores may be made of wire strands to procure additional strength, but they are not so flexible.

The wire strands are usually twisted into rope in the direction opposite to the twist of the wires in the strand. Such rope is known as regular lay. When the wires in the strand and strands in the rope are twisted in the same direction the rope is known as Lang-lay rope.

Lang-lay rope is especially adapted to resist external wear and therefore gives very satisfactory service on slopes and inclines where idlers must be used, provided the drums and sheaves are large enough to keep within proper limits the bending stresses in this stiffer rope. Another advantage also in the use of Lang-lay rope is the avoidance of internal wear known as "nicking." In regular lay rope the wires of adjacent strands cross more nearly at right angles and bending of the rope causes grooves or "nicks" to be worn in the wires. In Lang-lay rope the wires in adjacent strands cross at so slight an angle that this difficulty is almost negligible. Lang-lay rope is more easily untwisted than the regular lay rope and is more difficult to splice properly; it is not adaptable for universal use and should not be used without first consulting the manufacturer.

In addition to the ropes of usual construction as heretofore described, there are a number of special constructions which have been developed to meet unusual conditions, such as flattened strand rope, non-spinning rope, steel clad rope, locked wire rope (used for track cable for aerial tramways), flat rope, and galvanized rope.

Galvanized wire rope is made for ship's riggings and as guys for derricks, smokestacks, etc., where exposure to the weather would corrode an ordinary rope. It should not be used for purposes of hoisting and hauling except in marine work, such as for running rope, cargo falls, mooring lines, hawsers, etc. The strength of galvanized rope is not over 90 per cent of ungalvanized.

Material and Strength

The strength of wire rope depends primarily upon the material of which the wires are made. The strength of wire varies from 45,000 to 280,000 lb. per sq. in., depending upon the material and method of treatment. There are three general classes or grades of rope: (1) iron, (2) cast steel, (3) plow steel.

Iron or low carbon steel rope is soft, very ductile, and of low tensile strength (from 60,000 to 80,000 lb. per sq. in.).

Iron or low carbon steel rope is used for drum type elevator cables and similar purposes where the loads are not heavy, and where the tendency to abrasion is slight and the drums are designed to prevent undue bending.

Cast steel rope, usually called crucible cast steel, has a tensile strength varying from 150,000 to 200,000 lb. per sq. in. Because of its greater strength and harder structure it is recommended for general hoisting purposes, such as mine hoists, derricks, coal hoists, freight elevators, etc.

Plow steel is made from open-hearth furnace steel of a higher grade, with a tensile strength of about 200,000 to 250,000 lb. per sq. in. It has about three times the strength of iron rope and is tougher than ordinary cast steel rope. Plow steel rope is now commonly used for heavy hoisting and haulage, such as dredges, heavy duty cranes and logging.

Drums and sheaves of the largest practical diameter are recommended for all wire rope installations. For protection of the rope, drums should be lagged if the radial pressure is not too great. Grooved drums are preferable.

Over winding—that is, winding the rope in two or more layers on a drum—should be avoided if possible, as it rapidly destroys the rope. Where practicable, the drum should be made long enough to take all the rope in a single layer.

New rope will not work properly and may be badly injured by running in sheaves that have become worn. To secure the best working conditions for rope it is sug-

gested that sheaves be replaced or that the grooves be turned up before used with new rope.

By reverse bending is meant the bending of the wire rope first in one direction and then in the opposite direction over sheaves or drums. This causes a severe strain on the rope and should be avoided. It wears out rope quicker than any other known cause.

All wire ropes, whether for inside or outside work, should be treated with a lubricant to keep them pliable and to prevent rust, which will stiffen the rope and result in poor service. Compounds of cylinder oil which will penetrate and lubricate the inner wires of the rope are best. It is important that the lubricant be free from acid or alkali. Wire rope running under water should be treated with a mineral or vegetable tar, fresh slacked lime being added to neutralize the acid.

Methods of Fastening Rope to Load

Rope is fastened to the load either by clips or by sockets. There is a difference of opinion among rope manufacturers and users as to which is the better method. It is agreed, however, that if the socketed joint is properly made, the load is more uniformly distributed on the individual wires than by the use of clips. The following directions for socketing wire rope are recommended:

1. Measure from end of rope a length equal to basket of socket. Serve at this point with not less than three wraps.
2. Open up strands and cut hemp center.
3. Untwist and separate the wires in the strands; it is not necessary that they be straightened.
4. Cleanse the wires with kerosene oil.
5. Dip wires into a solution of one-half muriatic acid, one-half water (use no stronger solution). Keep wires in long enough to be thoroughly cleansed (30 to 60 sec.).
6. Dip the wires into boiling hot water to which has been added a little soda to neutralize the acid.
7. Serve ends of cleansed wires so that socket may slip over all wires, and place in socket.
8. Cut serving wire at top and distribute evenly and level with top of basket.
9. Place fire clay around bottom of socket.
10. See that socket lines up with axis of rope.
11. Pour in molten pure zinc; do not use babbit. The zinc should not be too hot, but should be poured when it will cause a pine stick to char and ignite. About 700 to 800 deg. F. is hot enough.
12. Remove all servings except the one nearest socket. After cooling, the rope is ready for service.

Objections to socketing have been that there is a great possibility of poor workmanship and also that inspection of the socket may not reveal whether it is in safe condition. Some authorities, therefore, favor the clip fastening because it requires no special knowledge to make, and also because an inspection will reveal any defects.

It is now universally agreed that the most severe strain on a rope is at or near the point where the rope is attached to the load. For this reason it is highly important that whether fastening is made by socket, clips or clamps, a new fastening be made at intervals depending upon the length of service of the rope. It is also advisable from time to time to anneal the pieces comprising the connection to load to avoid crystallization. The use of "bridle" chains between the socket and load is suggested also as means of avoiding crystallization of the wires at socket. All fastenings should be remade at least once each four months. In the case of sockets, the following practice is recommended:

Intervals for Resocketing Ropes

Average of length of service of rope	Maximum time between resocketings
1 to 10 months	1 month
10 to 25 months	2 months
15 to 21 months	3 months
21 to 24 months	3½ months
24 or more months	4 months

Proposed Refrigeration Standards

IT HAS been proposed by joint action of the A. S. R. E. and the A. S. M. E. to adopt the following as standards for tonnage basis for refrigeration, but final action has not as yet been taken.

A standard ton of refrigeration is 288,000 B.t.u.

The standard *commercial* ton of refrigeration is at the rate of 200 B.t.u. per minute.

The standard rating of a refrigerating machine using liquefyable vapor is the number of standard commercial tons of refrigeration it performs under adopted refrigerant pressures, the pressures to be measured outside of and within 10 ft. of the refrigerating machine, measured along the inlet and outlet pipes respectively. Adopted inlet pressure is that corresponding to a saturation temperature of 5 deg. F., and outlet pressure that corresponding to 86 deg. F.

A refrigerating machine is the compressor cylinder for a compression system; or for the absorption system is the absorber, liquor pump and generator.

Dat's Plenty; Eh, Rastus?

Rastus had been promoted from a yard man to assist Scipio, the fireman. He had often been bawled out for his slowness in getting the oil can—he persisted in calling it pot. Some of his colored friends were having a heated argument relative to the functions of the dashpot. Unable to agree, they addressed Rastus:

"Well, Brer Rastus, what we'se wants to know is what you-all knows about dat dar dashpot round 'bout an engine."

"What I'se knows? Well, it am de cause of all mah sorrows. Ebbery time dey hollers for it, if I'se don't dash after it jist likes I'se was runnin' from a cop bustin' up de crap game, dey raises hell. Dat's what I knows."

A report of special interest and value to engineers has just been released by the Director of the Bureau of Standards. It says in part: "During the past year the Bureau's co-operation with industries has been particularly close. The inauguration of new lines of work which was given a great impetus during the war has affected nearly every American industry and the Bureau has been able to be of considerable assistance to these manufacturers through accurate scientific data which it is able to furnish as the results of Bureau's researches."

Foundations for Machinery*

A Discussion of the Theory and Purpose of Machinery Foundations Together with a Working Sketch of a Proposed Arrangement. By N. W. Akimoff

THE WEIGHT of the Great Pyramid is approximately 5,274,000 tons, its base is 764 ft. square, and its height about 486 ft. It is built on leveled rock. The Washington Monument rests upon a bed of fine sand, 2 ft. thick. The piers of Brooklyn Bridge are founded 44 ft. below the bed of the river upon a layer of sand, 2 ft. thick which rests upon bedrock. The massive St. Isaac's Cathedral, Petrograd, is built on a swamp, and the piling has been so carefully proportioned that the exceedingly heavy doors of the cathedral swing easily, whereas the slightest lack of uniformity in settling would doubtless lock them. These well-known structures are here mentioned by way of illustrating the obvious purpose of the foundations upon which they rest. The object of such foundations is double: (1) To distribute the load in as nearly uniform a manner as possible; and (2) to secure uniformity in settling, as it is a well-known fact that all heavy structures settle, some to a considerable extent, 6 to 12 in. and sometimes even more.

Just how all this applies to foundations for all sorts of machinery, and in particular to rotative machinery, is not easy to say. Indeed, the weight, say, of a large pumping engine or of a turbo-generator outfit is generally much lower per square foot of floor space occupied than the limits prescribed by municipal laws or building ordinances, and furthermore, uniformity of settling of a relatively small volume of this nature (substructure plus engine, etc.) can be secured without going to the extremes usually observed in designing footings for buildings.

What, then, would be the general governing idea in proportioning a foundation, say, for an engine of a given type? Should it be heavy or light? Should it be deep, resting on rock or sand if possible? Should it be independent of the footings of the building, or would it be desirable to tie it to the latter?

By examining the existing records we can find a great variety of rather contradictory answers to each question, but the predominant idea in the mind of the designers appears to be somewhat as follows: Since the engine is likely to vibrate, let us tie it as firmly as we can to the earth itself. The mass of the earth being practically infinite, the amplitude of the resulting vibration will probably be zero. The designer may be utterly unconscious of this reasoning, but he applies it through instinct or "horse sense" and gets results which sometimes are satisfactory and sometimes exceedingly poor.

It is especially interesting to see how the same designer, having decided to provide as solid a foundation as practical considerations allow, will often unconsciously neutralize his whole theory by such means as: (*a*) resting the foundation upon a layer of rubber, cork, felt, or other yielding material (see Fig. 1, *A* and *B*); (*b*) providing a space between the foundation and the walls of the building and filling it with sand (if the foundation is so heavy and so deep as to secure immunity from vibrations, why fear its contact with the walls?); (*c*) using various pads, buffers, cushions, etc. (see Fig. 1, *C* and *D*), which, if at all yielding, of course tear to the ground the very idea of solidity of the foundation with the earth.

Causes of Vibration

Vibrations are caused by two distinct orders of agencies: (1) Those due to unbalance, or, more correctly, lack of running balance; and (2) those due to causes other than unbalance.

As regards unbalance, it may be said that this can be so easily corrected in the construction of machinery that all specifications should invariably call for perfect running balance at all speeds, that is, complete absence of tremor or of "periods" under all conditions. However, there are many causes quite independent of balance, each of which is likely to result in vibrations, as

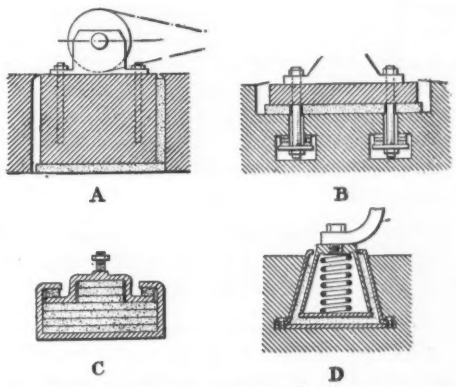


FIG. 1. SOME METHODS OF NEUTRALIZING VIBRATION

for instance, "whipping" of a slender body (crankshaft, armature, turbine rotor, etc.); water in a steam turbine; peculiarities of the reciprocating mechanism, etc. Our problem, then, is to analyze the effect of these various causes, with the view of designing a substructure for a given machine that will be *least responsive* to these causes, for this is what the "relative" freedom from vibrations really means.

If the body is rigidly locked so that no displacement of any kind is possible, we say that all six degrees of freedom have been suppressed. By fixing two points in the body we have the effect of rotation about an axis, and only one degree of freedom, that is, the angular displacement about the axis, characterized by these two points. By fixing one point we suppress all bodily motion along any three axes through this point, but we still have three degrees of freedom, that is, freedom of angular displacement about any or all three axes.

On the other hand, placing a body upon a thick sheet of yielding material, or for that matter on four springs, means freedom in all six directions; and of course the same applies to cushions or pads. For this reason it appears to be of extremely questionable value to interpose layers of such material between a massive sub-

* Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers.

foundation and the foundation proper of a machine, even if isolated examples are on record where such an arrangement actually *happened* to give satisfactory results.

What Is Stability?

With the foregoing in mind, let us digress for a moment. Stability with regard to our subject is a somewhat relative term. Why was the Great Pyramid built upon leveled rock, even, we are told, dovetailed therein? To insure stability. Why build a massive foundation for an engine? To secure stability. Why provide a layer of yielding material or springs or rubber pads? To secure stability.

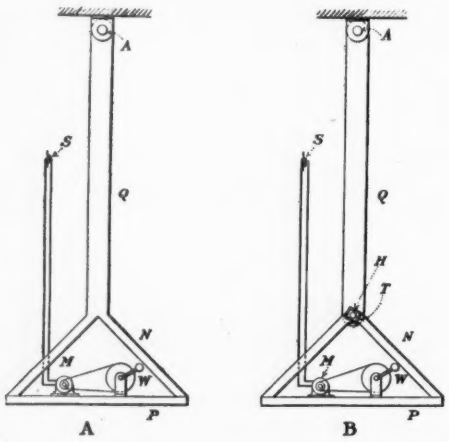


FIG. 2. (A) SYSTEM WITH ONE DEGREE OF FREEDOM. (B) SYSTEM WITH TWO DEGREES OF FREEDOM, ONE OF WHICH MAY BE SUPPRESSED

In large power plants where turbo-generators are used, steam mains have been known to burst and often the only cause to which the accidents could have been attributed was vibration. The operating of a printing plant is often extremely unpleasant for persons in adjoining buildings. Inspection often reveals that machinery is firmly secured to massive foundations and the owners are at a loss as to how to remedy the trouble. Too much rigidity in an understructure is as harmful as too much freedom to yield.

Stability in foundations characterized by remoteness of the operative speed from any one of the several synchronous speeds at which the frequency of the operative speed would be nearly, or exactly, equal to the frequency of the free oscillation of the system, if displaced from natural state of rest and let go.

How many distinct synchronous speeds a system is capable of having depends upon the number of degrees of freedom. An absolutely free system, for instance, placed upon an elastic sub-foundation, may have six independent synchronous speeds, or "critical" speeds, as they are sometimes called. A system with one fixed point may have only three such synchronous speeds, while a system mounted to rotate about an axis can have only one such speed or "period," as it is often termed. If we could control these synchronous speeds, so as to make sure that none comes anywhere near the actual speed of operation of the machine, we would then have a fairly complete solution of our problem.

Vibration in a Body with One Degree of Freedom

In order to understand clearly the foregoing as well as the broad methods here proposed, let us consider the following experiment and the general consequences manifestly derived therefrom: Imagine a pendulum (Fig. 2A) consisting of a platform P rigidly connected to the member Q by means of the side members N. The system is free to swing about the axis A in the plane of the figure. A small motor M fastened on the platform P operates a countershaft carrying an off-center weight W. The motor is fed through a suitable flexible connection and it is always possible to adjust the speed of the countershaft carrying the weight W so that the number of revolutions per minute of the former will be equal to the number of double oscillations per minute of the pendular system, if the latter is slightly displaced from its vertical position of equilibrium and let go. The effect of this adjustment of speed will be the so-called "synchronism," and the extent of swing (amplitude) of the pendular system, in general very slight for arbitrary values of the rotative speed of the weight W, will now become violent, in fact, out of all proportion to the magnitude of the weight W itself.

Vibration in a Body with Two Degrees of Freedom

As a modification of the experiment let us now provide another system (Fig. 2-B) identical with the first except that the platform P is not solid with the member Q but is pinned thereto at H, the pin used being

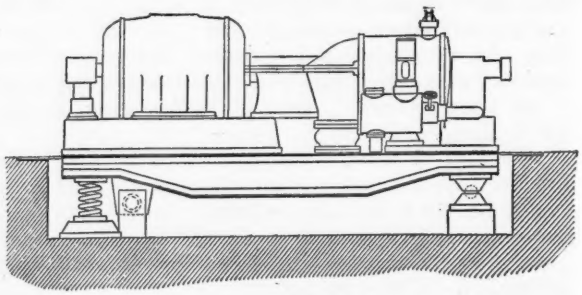


FIG. 3. APPLICATION OF AUTHOR'S DESIGN TO A TURBO-GENERATOR

both frictionless and at the same time so arranged that it can be tightened up by means of the nut T, so as to lock the joint, thereby securing the exact effect of the rigid pendular system of Fig. 2-A. In experimenting we shall first deal with the system of one degree of freedom, tightening the nut T and thus converting the pendulum into a system exactly similar to that discussed above, the synchronous speed being, say, 100 r.p.m. The pendulum will oscillate violently. We now loosen up the nut T, introducing an additional degree of freedom, with the apparently surprising result that the amplitude decreases practically to zero. If we reduce the speed considerably, say to 50 r.p.m., violent oscillations of the whole system will reappear, as will likewise be the case in speeding up the countershaft, say to 150 r.p.m. These figures are purely illustrative; whether they will actually correspond to exact facts will of course depend upon the characteristics of the system.

In other words, by introducing an additional degree of freedom we have accomplished this double result: (1)

What was synchronous speed for a system with a single degree of freedom is no longer synchronous speed for the same system provided with an additional degree of freedom; (2) the new system has two frequencies of oscillation, at which it is sensitive to disturbing influences (such as centrifugal action of the weight W), one being below and the other above the value corresponding to that of the same system with the additional degree of freedom suppressed.

The Basis of Foundation Design

This, then, will be taken as basis for our further discussion: In contemplating the design of a foundation we shall always separate those directions (or axes of instantaneous rotation) about which the system cannot (or at least is not likely to) oscillate from those directions (or instantaneous axes) about which the system is more or less certain to vibrate. We next shall select a "steady" point from purely practical considerations, and finally devise such means of controlling the "free periods" of the system as will secure the desired degree of remoteness from synchronism under the actual operative speed. Such means of course will be springs, exceedingly heavy, and not in the least calculated to allow of any free wabbling of the system.

Applying the foregoing principles to the design of a setting for a turbo-generator (Fig. 3), we must start out with the selection of the steady point. We will naturally place it as near the steam main as possible (not to the exclusion, of course, of a suitable expansion joint), as under all conditions, should there be a choice of position, preference should be given to that point as far as possible from the center of gravity of the system, so that any static unbalance (whipping, etc.), would be made to act not as a force *upon*, but as a moment *about* that steady point. Such point should actually be made as steady as possible and no trouble should be spared in providing suitable piling or digging down to the solid ground and constructing suitable footings.

The next problem is to design a substructure adapted to receive the bedplate of the apparatus and made stiff enough so as to eliminate any "periods" of its own. This bedplate may be made of structural steel or of reinforced concrete, in which latter case the ends thereof may be made of cast iron. The substructure is supported upon the steady point either by a ball-and-socket arrangement, or is simply bolted at that point to the floor plate underneath by a bolt which need not necessarily be very light but which must be arranged in a manner to secure the minimum area of actual contact. In apparatus of this sort we have practically only two degrees of freedom and only two periods to adjust so as to have them well out of the limits of the operative speed. Hence the two sets of springs, one to take care of the period corresponding to oscillation in the vertical plane, the other to control motion in the horizontal plane. It should not be imagined, however, that these springs will necessarily be very light; they will always have considerable stiffness, but their function is that of being the only members that *can* yield and the whole situation is controlled by the proper choice of these yielding elements.

Changes in Massachusetts Boiler Rules

Changes Adopted at a Public Hearing Held by the Board of Boiler Rules

RECENTLY a public hearing was held by the Board of Boiler Rules to consider changes in the rules and the following were adopted:

Repairs and appurtenances, as well as boilers originally installed must comply with the provisions of the rules.

Rules of Part III apply to new installations. These relate largely to materials, construction and inspection, and have been considerably modified from the former code.

Wording of the paragraphs in Part II relating to gage cocks has been changed for greater clearness, but without change in intent.

Blow-down for the water column is to be placed at the lowest point in the water connection, to be of at least ½-in. pipe, and a globe valve of the same size as gate valve may be used in addition to the gate valve.

In the certificate of inspection, the "Year first placed in service" is substituted for "Age in years," and error in wording regarding dimensions of the certificate is corrected.

Specifications for materials, Part III, are amplified and made to conform with a few exceptions to those of the American Society for Testing Materials of October, 1914, and the A. S. M. E. code. All steel is to be open hearth, but may be from either basic or acid process. Extra soft or "flange" steel is not permitted for boiler plate.

Some difference is used in the method of determining modifications of test elongation allowed in the direction of simplicity and definiteness, but results would not be altered materially.

Requirements for test specimens are explicit. Tension specimens are to be from the bottom of the rolled material taken in the direction of the axis of the ingot. Bend specimens are to be from the middle of the top of the rolled material taken transverse to the axis of the ingot.

For the bend test, presumably on account of transverse specimens being required, less severe requirements are made; for material 1 in. or less thick around a pin whose diameter equals the thickness of the specimen; and for material over 1 in. thick around a pin with diameter twice the thickness of the specimen; without cracking on the outside of the bend. No "quench bend" test is required.

Marking of plates is required as in the former Massachusetts rules, but for heads and butt straps the rules of the A. S. M. E. code are adopted. Inspection and rules are as for the A. S. M. E. code.

Specifications for rivet steel, for stay-bolt steel, for steel boiler rivets, for steel bars, for steel castings, for

gray iron castings, for malleable castings, for boiler rivet iron and rivets, for stay-bolt iron, and for refined wrought iron bars are the same as in the A. S. M. E. code in all respects.

For lapwelded and seamless boiler tubes, there is a variation from the A. S. M. E. code in regard to the flange test: For tubes not more than 6-in. diameter, with thickness less than 10 per cent of the outside diameter, but not exceeding No. 6 B.W.G., a test specimen not less than 4 in. long shall have a flange turned over at right angles to the body of the tube without cracking or showing any flaw. This flange, as measured from the outside of the tube, shall have a width of from ⅛ in. to ½ in., the width between these limits to be not less than 10 per cent of the outside diameter of the tube. For other tubes the flange test is not required.

In the flattening test, the Massachusetts rules require that a specimen 3 in. long shall stand flattening between two parallel plates until the distance between the plates is not over *five* times the wall thickness without showing cracks or flaws, the weld, for lapwelded tubes being at the joint of maximum bend.

For the hydrostatic test the requirement is 1000 lb. per sq. in. for under 5-in. diameter, and 500 lb. for 5 in. and over, but fiber stress is not to exceed 16,000 lb. per sq. in. If it should so exceed, test pressure is to be: $p = 32{,}000\ t \div D$, where t is the wall thickness and D the inside diameter, both in inches.

On "workmanship" the Massachusetts rules require that tubes 3½ in. or less in outside diameter shall be circular within 0.02 in. and the mean outside diameter not to vary more than 0.015 in. from the size ordered. For tubes over 3½-in. diameter, variations shall not exceed 0.5 per cent of the outside diameter.

Each tube is to be marked with name or brand of the manufacturer, the material from which made and the pressure (lb. per sq. in.) at which it was tested, legibly stenciled. In other respects, requirements for boiler tubes are as in the A. S. M. E. code.

The rules for material to be used in boiler construction are changed in the following respects:

For shell plates and heads, extra soft steel is *not* allowed, open-hearth fire-box steel being required.

Rivets may be of steel or iron, conforming to specifications of the code.

Cast steel wherever used is to conform to the specifications for steel castings of the code.

Cast iron, wherever permitted, is to conform to the code specifications for gray iron castings.

Cross pipes, connecting steam or water drums of water-tube boilers, and all pressure parts over 2-in. pipe size or equivalent cross-sectional area shall be of wrought or cast steel of Class B grade as given in code specifications for steel castings when maximum allowable working pressure exceeds 160 lb. per sq. in.

Mud drums for other than heating boilers are to be of Class B grade steel.

MAXIMUM ALLOWABLE WORKING PRESSURES FOR TUBES FOR WATER-TUBE BOILERS, FOR DIFFERENT DIAMETERS AND GAGES OF TUBES

Outside diam. of tube in inches,	Gage—B. W. G.												
	17	16	15	14	13	12	11	10	9	8	7	6	5
D	t=0.058	t=0.065	t=0.072	t=0.083	t=0.095	t=0.109	t=0.120	t=0.134	t=0.148	t=0.165	t=0.180	t=0.203	t=0.220
½	434	686	938	1334	...	...	...	...	...	...	...	...	...
¾	206	374	542	806	1094	...	...	...	...	...	...	...	...
1	...	218	344	542	758	1010	...	...	...	...	...	...	...
1⅛	...	166	278	454	646	870	1046	...	...	...	...	...	...
1¼	...	124	225	383	557	758	916	1118	...	...	...	...	...
1½	...	...	146	278	422	590	722	890	1058	...	...	...	...
1¾	...	...	...	203	326	470	583	727	871	1046	...	...	...
2	...	...	...	146	254	380	479	605	731	884	1019	...	...
2¼	...	...	...	...	198	310	398	510	622	758	878	1062	...
2½	...	...	...	...	153	254	333	434	535	657	765	931	1053
2¾	...	...	...	...	117	208	280	372	464	575	673	824	935
3	...	...	...	...	...	170	236	320	404	506	596	734	836
3¼	...	...	...	...	...	...	199	276	354	448	531	658	752
3½	...	...	...	...	...	...	167	238	310	398	475	594	681
3¾	...	...	...	...	...	...	139	206	273	355	427	537	619
4	...	...	...	...	...	...	...	178	240	317	385	488	565
4½	...	...	...	...	...	...	...	...	186	254	314	406	474
5	...	...	...	...	...	...	...	...	142	204	258	340	402

$$P = \left(\frac{t - 0.039}{D}\right) 18000 - 250$$

Where P = Maximum allowable working pressure, lb. per sq. in.
t = Thickness of tube wall, in.
D = Outside diameter of tube, in.

NOTE: Maximum allowable working pressures for superheater tubes shall be the same as for boiler tubes.

Pressure parts of superheaters separately fired or attached to stationary boilers unless of locomotive type are to be of steel conforming to specifications for Class B grade steel castings.

Cast iron shall not be used for nozzles, or flanges attached directly to the boiler, nor for superheater mountings, valves or their bonnets for steam temperatures over 450 deg. F., but this does not apply for boilers to carry 15 lb. or less per sq. in.

Water leg and door-frame rings of vertical fire-tube boilers and of locomotive and other type boilers shall be of wrought iron or steel or of cast steel of Class A or Class B grade as per code specifications for steel castings.

The age of a Massachusetts standard boiler shall date from the time the first certificate to operate is issued, and the year in which that certificate is issued shall be stamped by an authorized inspector underneath the Massachusetts standard stamp.

An error in the stamping of a boiler may be corrected by any authorized inspector of the shop inspecting in-

surance company upon satisfactory proof and identification of the boiler, such correction to be made in the presence of a boiler inspector of the division of inspection of the Department of Safety of Massachusetts, who shall certify to the changes so made to the chief of inspections of said department.

Paragraph 9 on longitudinal joints is changed to *omit* vertical tubular and locomotive type boilers. It now provides that horizontal return tubular boilers with butt and double strap construction shall not have a continuous longitudinal joint over 12 ft. in length.

Minimum thickness of cast-iron nozzles where permitted is to be found by the formula heretofore used, but S, the ultimate strength of cast iron is to conform to specifications for gray iron castings.

A new requirement, Para. 46b, sect. 4, part 3, is added in regard to Tubes for Water-Tube Boilers. The minimum thickness of tubes and nipples measured by Birmingham w.g. for the various diameters and maximum allowable working pressures shall be as in the accompanying table, except that the two rows of tubes first exposed to the products of combustion shall be one gage thicker.

Para. 46c, sect. 4, part 3, on Tubes for Fire-Tube Boilers states that: The minimum thickness of tubes used in fire-tube boilers, measured by Birmingham w.g. for maximum allowable working pressures not exceeding 175 lb. per sq. in. shall be:

Diam. 1 in. or over, but less than 2½ in., No. 13 B.w.g.
Diam. 2½ in. or over, but less than 3¼ in., No. 12 B.w.g.
Diam. 3¼ in. or over, but less than 4 in., No. 11 B.w.g.
Diam. 4 in. or over, but less than 5 in., No. 10 B.w.g.
Diam. 5 in.....No. 9 B.w.g.

For each increase of one gage in thickness above that given above, the maximum allowable working pressure will be increased by, 200 lb. ÷ diam. of tube in.

Para. 52, sect. 4, part 3, when necessary to place a fusible plug in a tube, the tube shall be extra thick, not less than 3/16. in of *No. 7* gage.

Para. 53a, sect. 4, part 3, in regard to cast steel is omitted as the matter is covered in specifications adopted for steel castings.

Regarding support of h.r.t. boilers, if a suspension is desired other than that specified in the rules, the manufacturer is to submit blueprints to the board, which may, if it approves, permit such construction.

Para. 2, sect. 5, part 3, is changed to locate the safety valve on a superheater near the steam *outlet*.

The changes are in the interest of greater clearness and definiteness of requirements, hence are an advance and improvement.

Tender Stuff

As is always the case, the young superintendent was showing her through the factory.

"And this," he concluded as they finally reached the boiler shop, "is where they make the locomotive boilers."

"Oh," gasped the sweet young thing, "how strange! I didn't know they boiled locomotives."

"Yes they do," replied the young man with murder in his heart. "You see, that makes the locomotive tender."

Automatic Draft Regulation

THE FUNDAMENTAL PRINCIPLES INVOLVED IN DESIGN OF DRAFT REGULATING APPLIANCES. BY JAMES L. KIMBALL

THE FIRST essential to satisfactory combustion is to maintain a balanced condition in which the air supply to the furnace will always be in proportion to the load condition, as indicated by the pressure.

The relative value of draft regulators cannot always be determined by the sensitiveness of the apparatus for the reason that close regulation of the steam pressure is not always associated with fuel economies, in fact, it is oftentimes the reverse.

It is possible to maintain uniform steam pressure by a continuous and sudden varying of the air supply to the furnace, but if such changes were in success of the changes in load conditions, the result would be worse than no automatic regulation at all. The load requirements, as indicated by the pressure, should be in relation to the furnace output at all times.

Assuming that the requirements have been correctly stated, the question then arises, how can these results be best obtained? It is conceded by the leading combustion engineers that the hydraulic pressure regulator operating a throttling valve, located in the supply pipe to the fan engine, or connected direct to main or uptake dampers to be the most satisfactory appliance for the purpose.

All hydraulic regulators have three essential elements in their construction, namely: a diaphragm or pressure chamber, a pilot valve, and a motor cylinder. The best results will be obtained when a step by step or graduated compensative device is employed in the construction of these regulators, which will permit of a certain variation between maximum and minimum stroke of the motor plunger and the regulator operates incrementally between these extremes; such regulation will be productive of a uniform furnace temperature in harmony with the load conditions as indicated by the pressure.

The difficulty which has been encountered with this type of regulator in connection with forced or induced draft, is that the movement of the hydraulic plunger is too slow to be brought into step with the steam flow through a valve which is too large for the requirements. If the valve is too large and only requires a slight lift for maximum speed of the fan engine the changes in speed will be too sudden and the regulator will be unable to respond in time to prevent hunting action. As it will be found impossible to determine in advance the correct size of valve to use in every case, the best solution is to use an adjustable type of valve which can be adjusted to effect gradual changes in speed, and, in this way the regulator will not travel past the point where it should have stopped, all of which tends to harmonize the relations between the valve and regulator, and bring them into step.

Attempts have been made to operate draft regulators from steam flow; but a careful study of such methods as have been employed will show that such regulators are controlled primarily from pressure.

In the so-called operation from flow, the diaphragm

or pressure chamber is connected back of an orifice plate in the main steam supply line and in this way it has been attempted to anticipate changes in pressure from the steam flow; but in doing so, it has been found necessary to damp the action of the regulator to an extent that one cancels the other and the benefits from such a method, if any were possible, are of no account.

It is agreed that all boilers are most efficient at a certain rating depending on various conditions and above or below this rating the efficiency is less, but as it will in most cases be found impossible to operate continuously at the point of maximum efficiency, the best that can be done is not to change the rating of the boiler from its maximum efficiency point more than is necessary to effect necessary changes in load, and nothing of value will be gained by anticipating such changes before they are actually indicated by the steam pressure.

It is not at all uncommon to note a fluctuation of one or two pounds in the main supply pipe due to the intermittent action of reciprocating engines and pumps. Imagine what would be the effect on a regulator of sensitive action should we augment the pulsation by connecting the diaphragm back of an orifice plate.

The best practice is to connect the diaphragm or pressure chamber to the dead end of the steam header so the regulator will feel the true pressure and to avoid as far as possible making connection at points in the supply pipe which are subject to changing velocities, which more readily convey pulsations to the pressure chamber.

Until such time as apparatus can be developed and its complete dependability absolutely proven, the engineering profession will be slow in discarding the present logical method of controlling the air supply to the furnace by the variations in pressure which appears to be the most direct and unfailing indication of the relations between the boiler load and the furnace output.

A Pipe Ladder for Industrial Plants

By Henry Brady

CHEAP substantial ladders are often required. They should be of a type that can be readily erected by the ordinary workman in the plant and should be built of materials which are easily obtainable. Also they should be strong to minimize the possibility of accidents.

Ladders of the type illustrated and described in this article have been used in the industrial plants operated by a certain corporation for a number of years. They have given complete satisfaction. They are cheap, strong, and are readily assembled and erected. The design is such that a ladder built in accordance with it is very compact, and can be modified so as to satisfy the requirements of practically any location.

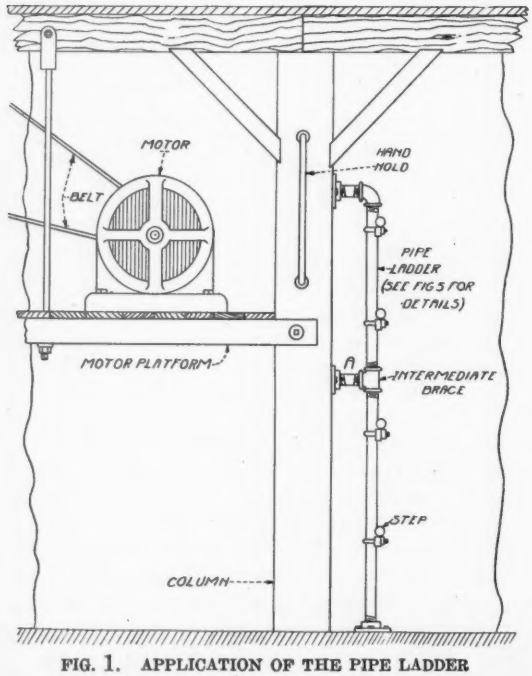


FIG. 1. APPLICATION OF THE PIPE LADDER

Figure 1 shows one of the ladders installed, and Figs. 2 to 5 inclusive indicate the details of construction. The ladders column is a piece of 1½-in. standard weight wrought iron pipe, or 1½-in. electrical conduit. Wrought iron pipe is ordinarily used if available, because it is the cheaper.

The rungs are castings, which, for the ordinary application, require no machining. Each rung is held to the pipe column with a U bolt bent from ½-in. iron rod. In the typical application suggested in Fig. 1, the pipe ladder is installed between the floor and a platform supporting a motor that is mounted near the ceiling of the building. At the point where the pipe column rests on the floor and where it rests against the platform at its upper end, standard 1½-in. malleable iron floor flanges are used. Where the flanges rest against a wooden surface, they are held thereto with lag screws. If the surface is of metal, as it frequently is in structural steel buildings, the steel should be drilled and tapped and machine bolts should be used for holding the flanges.

With concrete surfaces, it is best to cast bolts suitably located in the concrete at the time it is poured; but if this procedure is not feasible, the concrete can be drilled and expansion bolts used for securing the flange.

Where the ladder exceeds a length of, possibly, 10 ft., intermediate braces should be used, as shown at A, Fig. 1, to insure rigidity. Each of these braces is made from a standard 1½-in. pipe tee.

At the upper end of the ladder, it is usually desirable to provide some sort of hand hold so that a workman, ascending and stepping off the ladder, will have something to grip to brace himself while he is stepping off. Suitable hand holds can be bent from ½-in. iron rod, or instead of these, malleable iron handles, such as are used for heavy doors, can be employed.

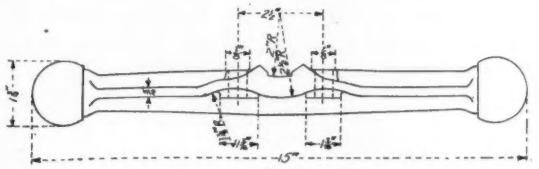
The pipe fittings required are always obtainable. The rung casting is made from a pattern, the dimensions of which are given in Figs. 2, 3 and 4. The tread of the rung is corrugated to prevent slipping of the workman's feet. The spherical knobs at each end afford a smooth

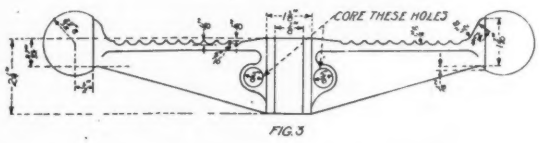
place to grip the hands while one is ascending. The holes for the accommodation of the U bolts can be cored. Where it is essential that the installation have a finished appearance, the body of the rungs should be painted black and the spherical knobs should be ground with an emery wheel so as to expose the bright metal.

The body of each rung has a T-section, which insures maximum strength with minimum material.

In Fig. 5, the erection details are indicated. The U bolt should be bent to a diameter of 1 29/32 in. so that it will set snugly around the 1½-in. pipe column. (The actual outside diameter of nominal 1½-in. pipe or conduit is 1.9 in.) The ends of each rod which is to be bent into a U bolt should be threaded before the bolt is bent, because after it is formed into shape, it is impossible to turn the die to cut the threads. Each end should be threaded for about 1 in. The best way to form these U bolts is to cut off and thread as many of the little rods as will be required; then each one can, after being brought to a red heat, be bent around a piece of 1½-in. pipe held in a vise. If this practice is followed, a good fit between the U bolt and the pipe is certain.

The rungs should be spaced along the columns about 12 in. between centers, and the lower rung should be about 18 in. from the floor. If it is placed too close to the floor, it may interfere with sweeping and traffic.





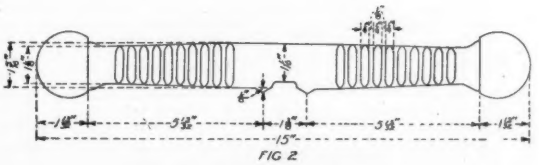


FIG. 2. TOP VIEW OF STEP
FIG. 3. SIDE VIEW OF STEP
FIG. 4. BOTTOM VIEW OF STEP

In communities where malleable castings can readily be obtained, an added factor of safety is provided if this material is used instead of the cast iron for the rungs. While the cast-iron rung shown in the illustrations has proved to be of ample proportions safely to sustain the weight of a man, malleable iron is, of course, much stronger, and is particularly useful for rungs which are located close to the floor. Unless a railing is built around the foot of the ladder, trucks being hauled about the plant may bump into them. Occasionally the cast-iron rungs are broken, due to this interference. Malleable iron rungs may bend, but will seldom break.

Where good clean castings cannot be obtained, the two cored holes through each rung for the accommodation of the U bolts should be ¾ in. instead of ⅝ in. in

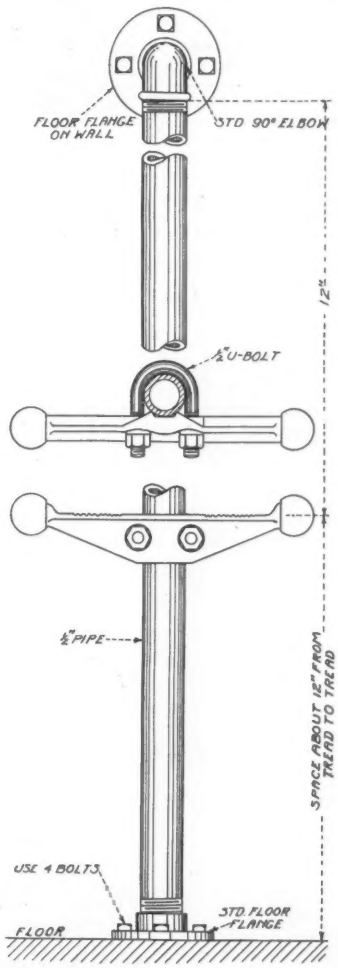


FIG. 5. ERECTION DETAILS OF LADDER

diameter. Where ¾-in. holes are used, standard ½-in. punched iron washers should be inserted under each of the nuts which turn on the U bolt.

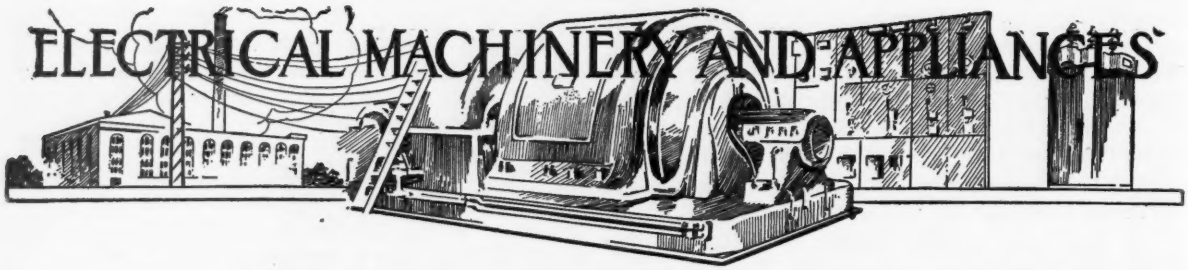
Death of Famous Engineer

IN THE death of Prof. Regis Chauvenet, which occurred at Denver, Colo., Dec. 5, the world loses one of its brightest engineers.

Prof. Chauvenet was born in Philadelphia, Oct. 7, 1842, the son of William Chauvenet, the renowned astronomer and mathematician, to whose untiring effort the institution of the Naval Academy at Annapolis was largely due.

Regis Chauvenet was president of the Golden, Colo., School of Mines from 1883 to 1902 and under his jurisdiction this school grew from insignificance until it ranks today as an honor to our country.

He was the author of many scientific books and papers and as a lecturer on such subjects as stoichiometry, theoretical chemistry, metallurgy in iron, steel, lead and zinc, he was without a peer.



Remodeling Switch Gears for Power Systems---I

REQUIREMENTS TO BE CONSIDERED AND MET; DETAILS OF OIL CIRCUIT BREAKER CONSTRUCTION. BY STEPHEN Q. HAYES

IN remodeling the switching equipment of a power plant, there are many features to be considered, due to the requirements of space, safety and flexibility.

Space is apt to be more limited in an old plant than in a new one, and the requirements of keeping the plant in operation, during the period of changeover, and the necessity of utilizing as far as possible the old equipment, introduce many limitations in the design and sometimes necessitate the use of apparatus or arrangements that would not be considered at all suitable for a new plant.

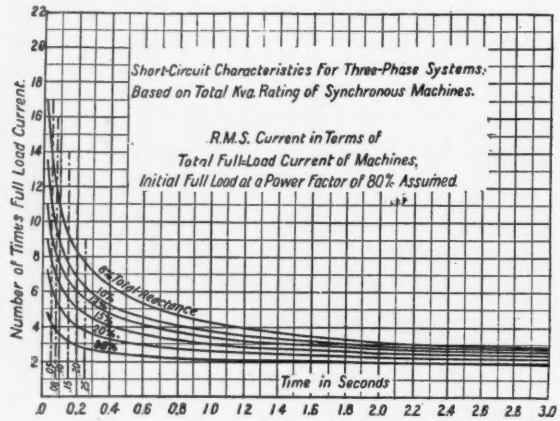

Short-Circuit Characteristics For Three-Phase Systems.
Based on Total Kva. Rating of Synchronous Machines.
R.M.S. Current in Terms of
Total Full-Load Current of Machines,
Initial Full Load at a Power Factor of 80% Assumed.
Number of Times Full Load Current.
Time in Seconds
30% Total Reactance
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0

FIG. 1. SHORT CIRCUIT CHARACTERISTICS, 30 PER CENT REACTANCE OR LESS

Space limitations of a panel switchboard using panel-mounted oil breakers can frequently be improved by changing these breakers to distant mechanical control as the cover-plates and operating handles occupy much less space than the breakers permitting the use of narrower panels or the controlling of more feeders from a single panel. The adoption of electrical operation for the breakers enables a still more compact arrangement to be utilized.

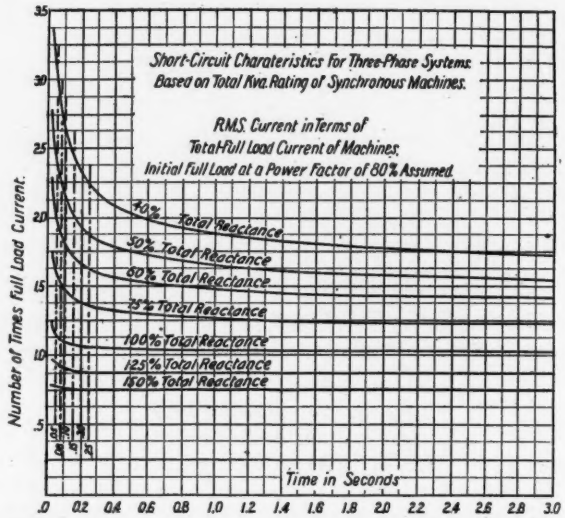
It occasionally happens that a station has been designed to accommodate turbo generators of a certain maximum size with the switchboard located along the side wall at right angle to the turbos, and the width of the station has been determined by the length of such units.

When larger units are installed, they sometimes extend into the space that was being reserved for the extensions to the panel switchboard, and this necessitates the removal of the switchboard to some other location and makes advisable the use of a control desk in place of a panel board.

ISOLATING FEEDER CIRCUITS

MANY SMALL plants have started with the simplest possible switching equipments, using a single set of busbars and no spare breakers, which arrangement may prove entirely satisfactory in a small plant that does not operate 24 hr. a day. When 24-hr. service is used, it becomes almost impossible to isolate certain important feeder circuits for the purpose of inspection or repairs.

In plants of this character, the remodeling of the switching equipment should contain a change to a double throw system or some arrangement that will permit the feeder circuits to be supplied from alternative sources.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Total-Full Load Current of Machines.
Initial Full Load at a Power Factor of 80% Assumed.
Number of Times Full Load Current.
Time in Seconds
40% Total Reactance
50% Total Reactance
60% Total Reactance
75% Total Reactance
100% Total Reactance
125% Total Reactance
150% Total Reactance
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0

FIG. 2. SHORT CIRCUIT CHARACTERISTICS, 40 PER CENT REACTANCE OR MORE

This can sometimes be arranged by providing such feeder breaker with disconnecting switches on both sides to isolate it not only from the bus, but also from the outgoing circuit. Two of these feeder breakers can then be so located mechanically as to facilitate a cross connection between the feeder circuits beyond the disconnecting switches that isolate the breakers from the feeders.

With such an arrangement, each feeder is normally supplied through its own breaker; but in case it is necessary to inspect or repair the breaker on any particular feeder circuit while maintaining current on the feeder, the cross connecting disconnects may be closed and the isolating disconnects opened so that breaker 2 will be completely isolated for inspection and repairs, although feeder 2 is kept in operation through feeder breaker 1.

Rupturing Capacity of Breakers

Probably the most important point to be considered in the remodeling of a power plant whose capacity has been greatly increased is the question of determining whether the oil circuit breakers furnished with the original equipment will have sufficient rupturing capacity when additional generators are installed.

Some of the earlier oil circuit breakers were installed without any definite guarantees as to the amount of power they could readily handle. In other cases, the large oil circuit breakers installed in the earlier plants were considered as having practically unlimited rupturing capacity, and were guaranteed capable of being able to open under any short circuit condition in the contemplated system.

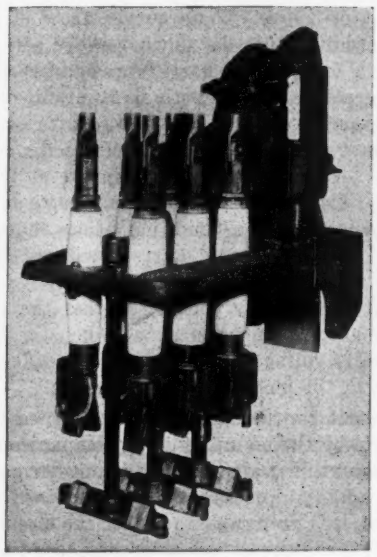


FIG. 3. WALL MOUNTED, REMOTE CONTROL OIL CIRCUIT BREAKER RATED AT 300 AMP., 7500 V.

As such power plants grew, however, it was found that even the largest breakers built up to that time had their limitations in rupturing capacity and arrangements were finally made by operating companies and manufacturers for tests at Chicago, Niagara Falls and other places where large amounts of power were available to determine the actual rupturing capacity limits of different types of breakers.

As the result of these tests, various improvements were made in the breakers and fairly conservative ratings were afterwards given, these ratings usually being based on the kv.a. capacity of a plant to which it was safe to connect a certain definite breaker. It was later appreciated that the short circuit conditions to be expected in power systems depend not only on the kv.a. capacity of the machines connected to the circuit, but also on their reactance and other characteristics.

Whether a breaker was to be used for automatic or nonautomatic service was also given due consideration, as the automatic breaker, if set to trip practically instantaneously on the occurrence of a short circuit, will have to open under far more severe conditions than if it were used for nonautomatic service.

To allow for these different conditions, one of the large electrical manufacturing companies assigned two series of ratings to its various oil breakers, giving them one rating when used on a system fed from low reactance

FIG. 4. 2000-AMP., 7500-V., FOUR-POLE BREAKER WITH TANK REMOVED

turbo generators, and a higher rating when fed from water-wheel units or higher reactance machines. For nonautomatic service, still higher ratings were given. Many breakers now in service had their guarantees made in this manner.

Another of the large electrical manufacturing companies based its circuit breaker ratings on the amperes in the arc at the time of short circuit multiplied by the voltage and expressed the current rupturing ability of a breaker in arc kilovolt amperes. To reduce this to a station capacity basis the following assumptions were made:

The generators of the turbo type were assumed to have an inherent reactance of approximately 8 per cent, giving a root-mean-square current on the first cycle of a symmetrical short circuit of 12½ times their rated full load current, the sustained short circuit having a maximum root-mean-square value of not more than three times their rated full-load current. Owing to the fact

that a large breaker set for instantaneous shunt trip requires approximately 0.25 sec. for opening, it was assumed that the current at the time the contacts opened, was reduced to approximately 50 per cent of that occurring on the first cycle, or in other words, to 6¼ times the generator rated full-load current. If the short was an unsymmetrical one giving higher current

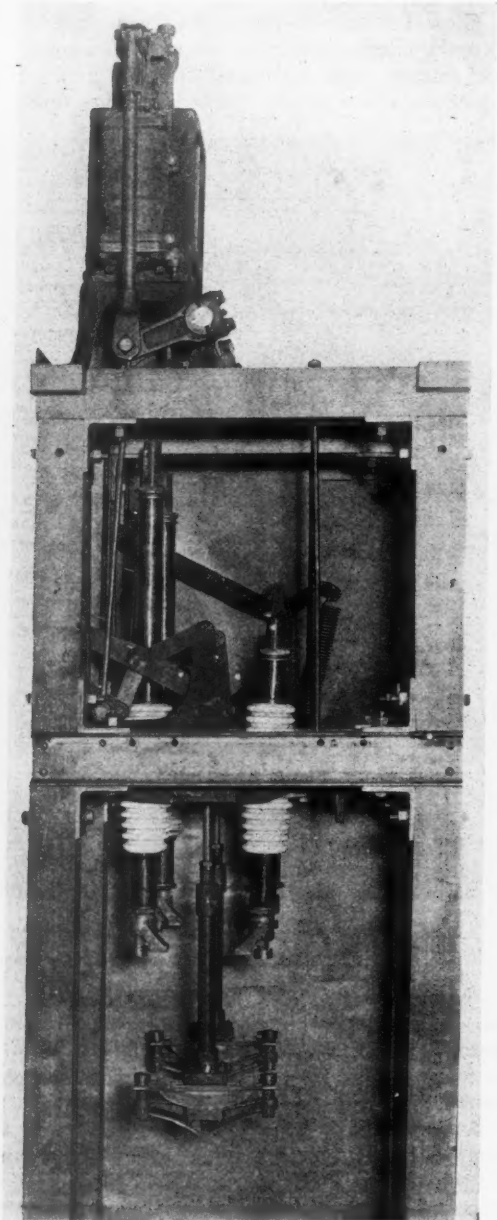


FIG. 5. CELL MOUNTING BREAKER WITH GUARANTEED RUPTURING CAPACITY OF 10,000 AMP. AT 15,000 V.

values for the first few waves, this lack of symmetry had practically died out by the time the breaker opened. The guarantees made on this basis were that the breaker would open at least three successive short circuits before the contacts needed to be repaired or the oil replaced, and that these short circuits might occur as close as 2 min. apart. It was further stated that the ultimate capacity for any reactance other than 8 per cent varied directly with the reactance.

As the continuous short circuit current of the generators was assumed to be, on the average, three times normal, and the short circuit for instantaneous operation assumed to be 6¼ times normal, a breaker for nonautomatic service or service with a 2-sec. time limit could be safely used in a plant of twice the capacity of that for automatic service.

Owing to the confusion arising from the different methods of guaranteeing the capacity of breakers, three of the engineers connected with circuit breaker design in the largest electrical manufacturing companies presented a joint paper before the American Institute of Electrical Engineers under date of February, 1918, and embodied in that paper a series of curves showing short circuit characteristics (based on generator design data secured from the manufacturing companies) for generating and transforming equipment with reactances varying from 8 to 150 per cent.

These curves, slightly modified for convenience, are reproduced in Figs. 1 and 2. Figure 1 gives a series of curves for reactances of 30 per cent or less, while Fig. 2 gives the corresponding curves for reactances of 40 per cent or more. These curves show clearly how the short circuit values die down rapidly after a small fraction of a second, and how the reactance of the system has a great deal to do with short-circuit conditions.

An agreement was also reached to express the rupturing capacity of oil circuit breakers as the current in amperes which they could safely rupture at their rated voltage two times with 2-min. intervals between the short circuits and still be in a condition where they could be closed and carry full rated current without inspection or repairs.

While it is generally considered that the rupturing capacity of an oil breaker increases when the breaker is used below its voltage rating, there are different ways of arriving at the amount of this increase.

The present rupturing capacities assigned to oil circuit breakers by the manufacturing companies are given on the basis outlined above, and in considering whether older switching equipment can be safely used in an enlarged plant, it is preferable to reduce the circuit breaker rupturing guarantees of the older breakers to the same modern basis of rating that is used for the newer types.

Due to changes in manufacturing conditions and the adoption of more conservative ratings, the rupturing capacity guarantees of the later breakers may prove to be slightly less than those assigned to corresponding breakers given under the older class of guarantees. Due consideration must be given to this fact when comparing the new and the older lines of breakers.

The comparative rupturing capacity of breakers with approximately the same characteristics depends on the volume of oil, the height of oil, the speed of opening, the use and location of arcing tips and similar features of design.

The actual rupturing capacity of an old breaker may have been reduced by the weakening of the oil tanks or their supports due to numerous short circuits, the slowing up of the speed of operation due to rust or wear, the burning of the main contacts or arcing tips from severe

usage, the loss of temper in the springs or brushes of the contacts and similar features, all of which should be given due consideration when estimating the rupturing capacity of an old breaker that has been in service for several years under severe conditions.

Details of Design

With the exception of one particular make of breaker practically all modern American oil circuit breakers are designed to have the open position maintained by gravity so that the contacts fall to the open position in case of injury to the moving contacts of the lifting rods. Rapid acceleration of the moving parts is obtained to minimize the duration of the arcing, the tank pressure, and the deterioration of the arcing contacts. All live parts are immersed under a deep head of oil to absorb the shock of short circuit and to prevent the excessive development of gases when rupturing large amounts of power.

Good design provides for the proper venting and baffling arrangements of oil tanks to provide regulated escape for the gases formed by rupturing heavy overloads and short circuits. Sturdy mechanical construction is needed throughout and it is preferable to secure wherever possible, isolation of individual poles in insulated cells on moderate voltage high capacity service, and in separate tanks on high voltages.

It is well to secure the use of generously proportioned high pressure wiping and self-cleaning contacts and to obtain the protection of the main contacts by arcing contacts so located that the main current exerts a blow-out effect on the arc.

Figure 3 shows a typical wall mounted, remote control oil circuit breaker, 300 amp., 7500 v., that has a guaranteed rupturing capacity of 2150 amp. at 7500 v.; 2850 amp. at 6000 v.; 4000 amp. at 4500 v.; 7700 amp. at 2500 v. Such a breaker, if used for direct mounting on a switchboard and consequently supplied without an accelerating device, would have its rupturing capacity rating reduced about 20 per cent.

This type of breaker is provided with wedge contacts on the movable parts, finger type contacts on the stationary parts, with auxiliary arcing contacts. A single tank is provided for all three poles and ample air space is allowed at the top of the tank for gas expansion. These tanks have insulated linings with insulated cells for the isolation of the separate poles.

A modification of this type of breaker has a separate individual tank for each pole and the breaker is built in modified form for outdoor service.

Figure 4 shows a 2000-amp., 7500-v., 4-pole breaker with tank removed. For the 1200-amp. and 2000-amp. sizes a common tank is used, but for the 300 and 600 each pole has a separate tank. This type of breaker has a guaranteed rupturing capacity of 3000 amp. at 7500 v., 4000 amp. at 6000 v., 5800 amp. at 4500 v., 11,000 amp. at 2500 v., 39,000 amp. at 750 v. The corresponding 600-amp., 15,000-v. breaker has a rupturing capacity rating of 1900 amp. at 15,000 v., 4400 amp. at 7500 v., 5600 amp. at 6000 v., 7800 amp. at 4500 v. and 14,300 amp. at 2500 v.

These breakers have a highly effective wiping and self-cleaning form of laminated brush contacts protected by liberally proportioned butt arcing tips. The opening of all contacts occurs under oil with the positive direct gravity break assisted by spring acceleration. The tanks are of heavy sheet iron with all seams lap welded, they are removable without disturbing the operating mechanism, and are provided with a high grade insulating lining.

When this breaker is used for automatic overload trip with remote control, an accelerating spring device is used to quicken the opening of the contacts, and this device assisted by the arcing contact springs gives to the moving parts an acceleration greater than that caused by gravity.

Figure 5 shows a type of breaker particularly adapted to cell mounting and built-in current capacities up to 2000 amp., 60 cycles, 15,000 v., with a guaranteed rupturing capacity of 10,000 amp. at that voltage.

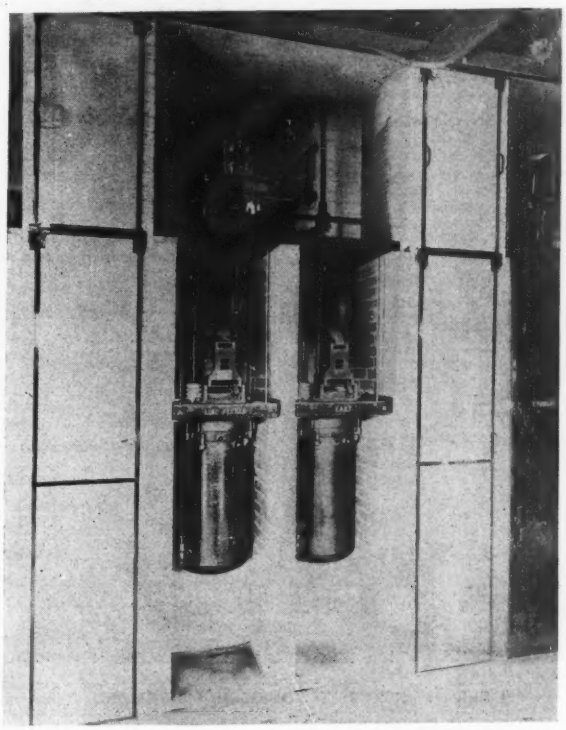


FIG. 6. OIL CIRCUIT BREAKER EQUIPPED WITH ROUND TANK

These breakers are made up of single-pole units, each having its own steel supporting frame and toggle arrangement for operating its moving contacts, so that all contact adjustments are made and locked before shipment. In the multipole breakers, these individual pole mechanisms are in turn connected to a common operating mechanism controlled by the manually operated handle and trip coils or by the electric operating mechanism.

The individual toggle arrangement for each pole permits each complete pole to be placed in position and properly lined up. This arrangement also permits the adjustment of contact pressure and contact travel of each pole to be made independent of the other complete breaker poles.

On the cell mounting breakers, the operating mechanism is mounted on a plate and channel frame structure fastened to the top of the cell structure. On the pipe

mounting breakers, the mechanism is mounted on the floor, to one side of the poles.

Each pole, with its cast steel top, is arranged to slide into a channel iron set in the barrier wall and it can readily be removed and replaced without interfering with other poles of the same or adjacent breakers.

Where still greater rupturing capacities in structure mounted breakers of the unit pole construction are desired, recourse is had to breakers with circular tanks of seamless pressed steel with rounded ends either of 16 or 20-in. diameter of the general design shown in Fig. 6. The breakers with 16-in. tanks are built in current capacities up to 1600 amp. with a rupturing capacity up to 18,000 amp. at 15,000 v., while the breakers with 20-in. tanks are built in current ratings up to 4000 amp. 60 cycles, 5000 amp. 25 cycles with a rupturing capacity of 23,000 amp. at 15,000 v.

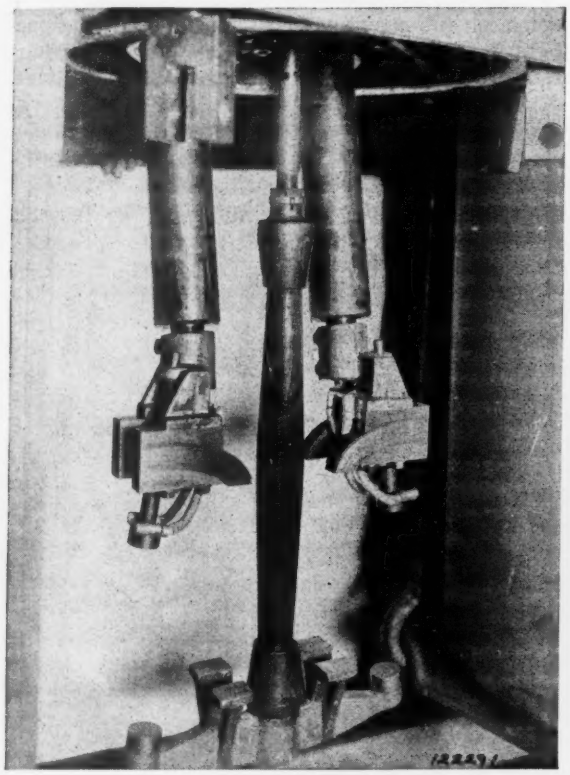


FIG. 7. REVERSED BRUSH ARRANGEMENT

Some of the latest improvements in large low-voltage breakers are the tank cradle and tie rod method of supporting the tanks to obviate the possibility of the tanks being blown off by an explosion and the furnishing of reversed brushes on all breakers where the short circuit current on the system might rise to such a point that the magnetic stresses would straighten out any ordinary brush of the usual wound copper strip construction. Instead of the brush in the form of a half ellipse being on the movable member that member is made essentially straight and brushes in the form of a quarter of an ellipse were placed on the stationary contacts and turned in with the concave side down so that the magnetic force increased the pressure between the stationary and movable members instead of tending to diminish the pressure by straightening out the brush when it was mounted with the concave side upward. The new moving element is so stiff mechanically that the magnetic forces cannot distort its shape. Figure 7 illustrates this feature.

In all these breakers, an accelerating spring is provided, as part of the complete breaker mechanism, to assist in forcing the breaker to the open position; an air cylinder dashpot in the lower portion of the spring container takes up the shock of the moving parts. The action of this dashpot can be adjusted by a screw needle-valve which regulates the size of opening of the dashpot valve.

The high interrupting capacity rating of these breakers is due to the form of tank, the use of steel supporting flanges with steel bolts, steel tops, large volume and head of oil, liberally designed arcing tips and the rapid acceleration of the moving contacts when opening.

Oil gages of the sight-glass form are supplied on each tank so that proper maintenance of the oil level is secured with a reasonable degree of inspection. Drain valves are supplied so that, when desired, the tanks can be emptied before lowering.

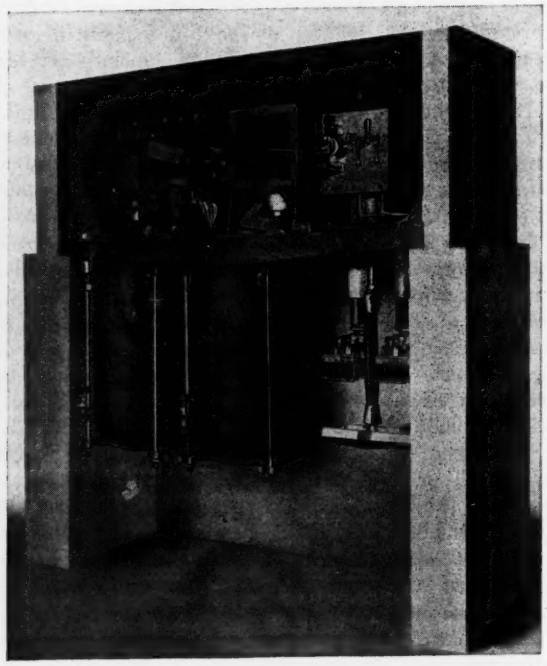


FIG. 8. A COMPACT BREAKER OF HIGH RUPTURING CAPACITY

The tanks are deep, providing ample space above the oil level as an expansion chamber for the arc gases and to prevent slopping of the oil from internal disturbances. The tanks are vented through specially designed check-valves, providing for the venting of gases, but at the same time preventing passage of oil.

Arcing contacts protect the main current carrying contacts. The arcing contacts open only after the main contacts have separated a considerable distance. As they are placed outside the main contacts, the magnetic blow-out effect of the current will blow the arc away from them so that the main contacts are fully protected from any possibility of arcing.

A modification of the design permits these breakers to be made for frame mounting and the mechanism can be placed on the floor at one side or in any of several different locations to suit the desired arrangement of the station.

Specially wide spacing has been used in a few particular cases where breakers were used with bus reactors and the pole spacing was to match that of the reactors.

Where great campactness and high rupturing capacity are desired, the type of breaker shown in Fig. 8 can be used. This has a unit type electric operating mechanism, forming part of an entirely self-contained breaker which requires no intermediate walls in the cell structure for supporting individual poles. The complete breaker is shipped as one piece, except for the doors and barriers, with all adjustments of contacts and mechanism parts locked, thus reducing the installation work.

These breakers are built only as three-pole units with tanks 16 or 20 in. in diameter. The breakers with 16-in. tanks built in sizes up to 2000 amp. 60 cycles, 2400 amp. 25 cycles for rupturing capacities of 18,000 amp. at 15,000 v. The breakers with 20-in. tanks are built in sizes up to 2400 amp. 60 cycles, 3000 amp. 25 cycles with rupturing capacities of 23,000 amp. at 15,000 v. These self-contained breakers are made for mounting in brick, concrete or steel structure compartments. The two outstanding features of the breaker are its compactness and its ease of installation. No intermediate structure walls are required for supporting the individual poles, all of them being supported from the common steel top. The breaker is supported in the structure compartment by means of anchor plates set in and projecting from the cell walls. The steel top of the circuit breaker rests on these anchor plates, and bolts hold it securely in place. The space between the circuit breaker top and the floor in front of the circuit breaker tanks is covered with removable doors. Three doors are furnished with each standard three-pole breaker. Each door consists of a metal frame with asbestos panels and hinged at the top of the mechanism base.

Insulators and Connectors for Crane Contact Wires

By C. M. Benton

FOR the average electric traveling crane, provided the contact wires are not too large, a No. 26 porcelain insulator can be used as a strain insulator, as indicated in Fig. 1. The galvanized iron wire that attaches the strain insulator to the termination fixture is passed twice around the groove of the insulator and its free end is made up about the main wire, as shown in the illustration. The contact wire is passed once through the No. 26 insulator, after having been inserted through the hole in a punched steel washer, and it is then brought back again through the hole as shown. This arrangement will hold it firmly.

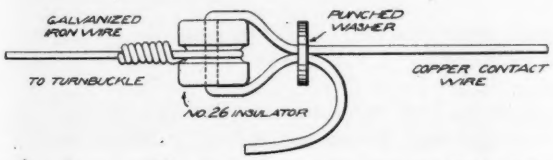


FIG. 1. NO. 26 KNOB USED AS A STRAIN INSULATOR

If the voltage impressed on the crane contact wire exceeds 125, two of the No. 26 insulators should be used in series between the contact wires and their terminal fixtures. For voltages higher than 250, three or more of the insulators can be used; but for such high voltages, it is usually preferable to use the brown glazed porcelain strain insulators that are designed for electric light and street railway construction. If the insulators of brown porcelain are not obtainable, those of the composition type can be applied.

Figure 2 indicates the outline dimensions of the No. 26 insulators. Inasmuch as the hole through the center of this is ⅝ in. in diameter, a large contact wire can be inserted through it; but as a general proposition, it is not wise to use the porcelain insulator of the type shown for a contact wire having a diameter exceeding ¼ in. If one endeavors to bend a larger wire through the insulator, the probabilities are that the porcelain will be cracked.

A homemade strain insulator can be assembled, as shown in Fig. 2, from materials that are always available. The strain insulator shown is made by clamping between two strips of ⅛ by 1¼-in. strap iron two No. 26 insulators. Bolts, ½ by 3 in., can be utilized to bind the strip to the porcelains. This arrangement has certain advantages over one like that of Fig. 1, for which galvanized iron wire is used to take the strain. There is always a possibility, in making up the iron wire, of nicking it with the pliers, which renders it liable to rupture when a severe strain is imposed. The two strips of the device of Fig. 2 are of such liberal section that there is no possibility of their breaking under any strain that they will ever be called upon to sustain. Furthermore, the arrangement at Fig. 2 has a more business-like appearance. An iron link or one forged from round

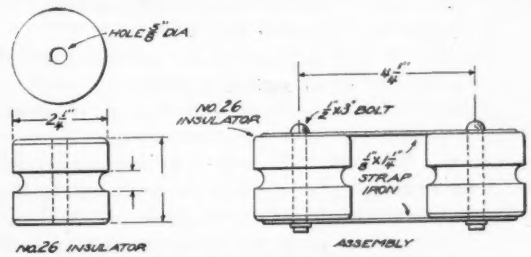


FIG. 2. A HOME-MADE STRAIN INSULATOR

iron rod can be used to attach the insulator of Fig. 2 to the terminal fitting.

Turn-buckles are frequently inserted between contact wires and the terminal fixture to provide means whereby the contact wires can be tightened. Obviously, strain insulators must also be used to separate the contact wires from ground and from each other. The insulation turn-buckle of Fig. 3 provides both insulation and a device for tightening the contact wire. Although it has been applied for crane-contact-wire installations in but a few instances, there is no reason why its application

should not be much more general. It is a commercial fitting, and can readily be obtained through any large electrical supply house. The metal parts are of forged

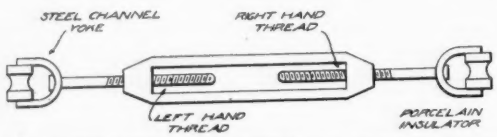


FIG. 3. INSULATED TURN-BUCKLE FOR CONTACT WIRES

steel throughout. The absence of castings is a feature that will appeal to the practical construction man. The yokes in which the porcelain insulators fit are bent from channel-section steel and the turn-buckle itself is a drop forging. One of the bolts has a left-hand and the other a right-hand thread, so that when the turn-buckle is rotated in one direction the bolts are drawn together, and when turned in the other direction they are forced apart.

DIMENSIONS OF TUBULAR CONNECTORS FOR CRANE WIRING

Number	L. Length in Inches	D. Outside Diameter in Inches	d. Inside Diameter in Inches	Largest Wire Accommodated	
				Solid	Stranded
1	1-7/8	11/16	.221	4	5
2	2	3/4	9/32	2	3
3	2-1/8	13/16	11/32	0	2
4	2-1/4	7/8	3/8	00	1
5	2-3/8	15/16	7/16	000	00
6	2-1/2	1	1/2	0000	000

Connectors, preferably of the tubular type, may be used for joining crane contact wires to the conductors which bring the energy to the crane runway. Most of the connectors on the market and used for this purpose are not of sufficiently sturdy construction to withstand the knocks that they receive around the average industrial plant. Figure 4 shows a detail and the accompanying table gives the important dimensions for tubular connectors of exceptionally liberal design for crane contact wires. The hollow cylinder forming the body of

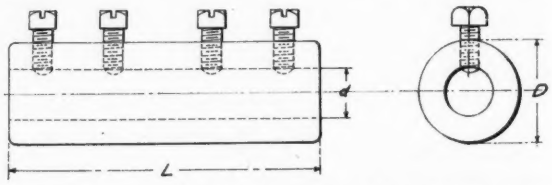


FIG. 4. TUBULAR CONNECTOR FOR CRANE WIRING

the connector is a piece of brass or bronze rod having a hole of the diameter indicated in the table drilled through axially. The set screws may be of case-hardened steel and at least ¼ in. in diameter.

Square or hexagonal-headed screws should be used, so that they can be turned with a monkey wrench or a pair of pliers. If square or hexagonal-headed screws that are also slotted across the head, as shown in Fig. 4, can be obtained, they are very convenient, as they can be withdrawn or inserted with either a screwdriver or a monkey wrench.

Engineering Notes from Abroad

INTERESTING ENGINEERING DEVELOPMENTS IN EUROPE AND SOUTH AMERICA. BY J. H. BLAKEY

AT THE session of May 3 of the French Academy of Sciences, Mons. G. Charpy presented a note by Mons. P. Morin on measurement of the flow of water over a dam by means of chronophotography, which is reproduced here in condensed form.

The method used is based on the following principle. If a luminous point of sufficient brilliancy moves in a plane parallel to the plate of a photographic apparatus (which must be without spherical aberration or other distortion), this plate will receive an impression which, on being developed, will give a faithful representation of the trajectory of the luminous point. If, in the plane in which the point moves, is placed a graduated measure of known length, the reproduction of the measure on the photograph will determine the scale of the picture. Finally, if the measure is carefully set with relation to a given point in the landscape, and if a toothed wheel, acting as an obturator, turns with a known constant speed in front of the objective, the resulting make and break of the image of the luminous point on the plate will give an accurate record of the rate at which the point moves. In addition, any variation in the rate of movement of the point will be indicated by a difference in the length of the segments of the line made by the point on the plate. Thus, on any part of the course of a stream, a mean velocity of the movement of the water can be arrived at; and as the speed of the lower sections is the same as that of the surface it is only necessary to know the mean depth of the water passing over the dam to find the volume of the flow in any given time.

In the experiments conducted by Mons. Morin, to obtain the luminous point a ball of silvered glass of 2⅜ in. diameter was used. This was weighted so that one-half of it floated above the surface of the water. The reflection of the sunlight from this floating half sphere gave a very satisfactory result, as is shown by the accompanying photograph. The ball is attached to a string so that it can be recovered at the end of the experiment. The image of this ball made a very clear impression on an ordinary photographic plate, even when moving at a speed of 8 in. per sec. upon the plate. The camera used had a simple objective of about 4 in. focal length, and a diaphragm of 0.2 in. diameter. The toothed wheel used had three equal teeth separated by spaces of the same breadth. In this particular experiment, the wheel was given a movement of 100 turns in 52½ sec., by means of clockwork. Thus each segment of the luminous point corresponds to a movement of the water during 0.0875 sec. The ends of the segments were so clean cut that they could be measured to one-third of a millimeter, which indicated a spacing of 2 mm. in the movement of the water. The lower dotted line in the photograph is a

line given by the same apparatus, the wheel turning at a higher speed; the purpose being to compare results at the two speeds.

The Removal of Sand and Gravel from the Feed Water of Hydraulic Turbines

Frequently it is found that the decantation basins which are used for the settling of sand and gravel in the feed water of hydraulic turbines, are insufficient for this purpose, and the result is a wear of vanes and valve seats which may put the plant out of commission in short order. This happens especially in mountainous regions, and at the hydroelectric plant at Santiago de Chili it was found that after less than one year of operation the turbines were so badly worn, that Mons. Henri Dufour, a Swiss engineer, was called in to remedy the situation. This he did by replacing the two existing decantation basins, which had required continuous alternate cleaning, by "de-sanders" of automatic and continuous action. These are of size suitable to the quantity of water to be treated, and are composed of a series of parallel rectangular compartments in which the water flows slowly, being retarded by transverse baffle plates. Arriving at the bottom of one end, it passes slowly below the baffles and finally over the top of the other end into the water chamber. The sand and gravel falls to the bottom of each compartment, and as this bottom is funnel-form, with the mouth constantly open, the deposit is carried

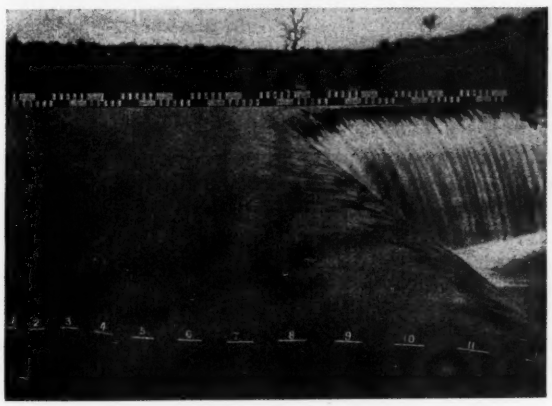


FIG. 1. MEASUREMENT OF THE FLOW OF WATER OVER A DAM BY MEANS OF CHRONOPHOTOGRAPHY

off by the small stream of water which escapes. Large valves, which are normally kept closed, are supplied for the complete and rapid washing out of the "de-sanders" when necessary.

This arrangement, which has been patented by Mons. Dufour, and which is described in detail in the Bulletin Technique de la Suisse romande, is in operation at the plant of the Societe La Lonza, in the canton of Valais, Switzerland, as well as at that of Santiago de Chili.

The Heating Powers of Different Liquid Combustibles

In the Journal des Usines a Gaz for July 5, Mons. H. Decluy gives the results of a number of calorimetric experiments made by means of a Mahler bomb calorimeter, on the heating values of some of the liquid combustibles in use in Europe.

Combustible	Heating Value—Absolute	Heating Value—Useful
Mazout (mean density 0.93)	10,600	10,000
Heavy tar oils	9300 to 9400	8950
Coal tar distilled at high temperature (mean density 1.02)	8800 to 8900	8550
Coal tar distilled at low temperature (mean density 1.08)	9300	8900
Schist oils	9450	9000

If the heat values per unit of volume are compared, the following results are obtained:

Mazout	9300
Heavy tar oils	9200
High temperature coal tar	8700
Low temperature coal tar	9600
Schist oils	9100

If a comparison is made of coal burned on an ordinary grate with these combustibles burned by atomiza-

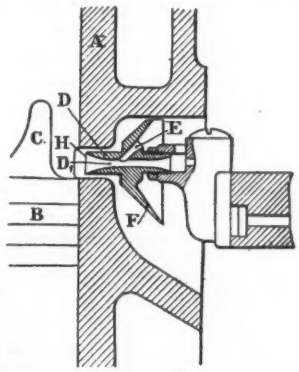


FIG. 2. IMPROVED FEED ATOMIZER FOR TWO-CYCLE INTERNAL COMBUSTION MOTORS

tion, the following results are obtained for the heat values for the vaporization of water:

Coal, burned on the grate	65 per cent
Coal, pulverized	78 per cent
Combustible liquids, atomized	79 per cent

To find the amount of an average steam coal which would be required to give the same heating value under a steam boiler, a coal having 15 per cent of volatile matter and 12 per cent of impurities was taken as a standard of comparison, and the following results were obtained:

	Coal burned on grate, tons	Pulverized, tons
One ton mazout was equal to	1.65	1.37
Heavy oils	1.47	1.23
High temperature coal tar	1.41	1.17
Low temperature coal tar	1.46	1.22
Schist oils	1.48	1.23

Mazout is a brownish black liquid remaining after the distillation of benzine and kerosene from Russian petroleum.

Improvements in Two-Cycle Internal Combustion Motors

Mm. E. W. Petter and A. M. Brown have obtained a French patent, No. 5,000,318, dated March 8, for such improvements, which consist in the method of atomizing the liquid combustible.

The piston B (Fig. 2) is provided at its top with a deflector, C, upon which the combustible is projected on leaving the atomizer, D. The atomization is the better

as the pressure upon C is greater, and therefore the dimensions given to the atomizer are such as to increase this value as much as possible. The air collector, F, of conical form, is for the purpose of inducing a pocket of air, which is drawn through the holes, E, of which there are several in the circle, into the narrowest part of the passage, D_1. This is made in the form of a Venturi tube, with the discharge end greatly enlarged in order to offer no resistance to the divergence of the spray. The presence of the air collector tends to increase the volume of the fluid, contributing to drive it into the motor, and thus increasing its speed, of which the degree of atomization is a function.

The Pourcell Compound Explosion Motor

The compound explosion motor recently patented by M. Leon Pourcell is characterized by the addition of an expansion cylinder B (Fig. 3) to a group of two admission cylinders A_1 and A_2, the arrangement being such that the expansion of the gases resulting from the explosion operates in the expansion cylinder at the same

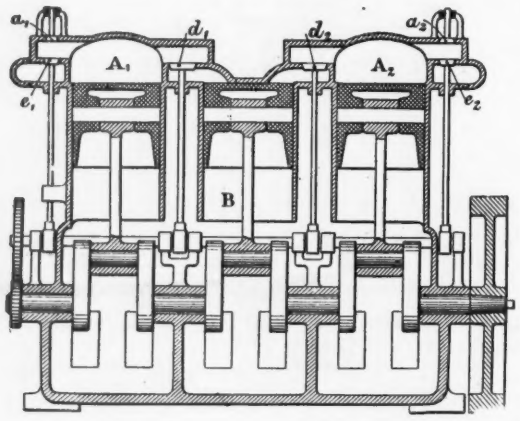


FIG. 3. DIAGRAMMATIC LONGITUDINAL SECTION OF THE POURCELL COMPOUND EXPLOSION MOTOR

time as in each admission cylinder. In the ordinary explosion motors an important fraction of the energy is lost by the fact that the pressure of the gases at the end of the explosion stroke is relatively high; it is generally about 40 lb. per sq. in. when the mean pressure is 70 lb. The inventor has sought a practical combination which would increase the volume of expansion during the explosion phase, in such a way as to recover a part of this wasted energy, while restricting the volume and weight of the engine as much as possible.

The motor is arranged in the following manner: A_1 and A_2 are admission cylinders provided with the usual means of distribution, the intake valves being at a_1 and a_2. Between these two cylinders is placed an expansion cylinder B. The cycles of the two admission cylinders are separated by 360 deg.; that is to say, the aspiration phase in cylinder A_1 corresponds to the explosion phase in cylinder A_2, and each cylinder arrives at the end of its stroke at the same time. The objection that such a motor is not balanced is met by using six cylinders, set as in an ordinary motor. The expansion cylinder, B, is put in communication alternately with A_1 and A_2 by the valves d_1 and d_2. The cam which actuates these valves is so set that each one lifts at the moment of explosion in the corresponding cylinder; it remains fully open during the explosion and also during the period of escape which follows; valves d_1 and d_2 therefore put alternately each one of the admission cylinders into communication with the expansion cylinder. The exhaust gases from B escape through valves e_1 and e_2, which are also the escape valves for cylinders A_1 and A_2, across the communication valves d_1 and d_2. There is no reason, however, why there should not be a special escape valve for cylinder B.

It is preferable to give the same dimensions to the three cylinders; the gases expand in a double volume, and the work of expansion is theoretically augmented by more than 30 per cent; in addition to this theoretical advantage, there is a saving of heat by the walls, for, by reason of the expansion, the mean density of the gas in contact with the wall is reduced almost one-half, and its mean temperature is much lower, in consequence of the lowering of temperature resulting from an adiabatic expansion in double volume. Thus the efficiency will be increased and cooling will be rendered easier.

The above is translated from Le Genie Civil of Oct. 9, from which also the cut is taken.

Laboratory Assistants, Bureau of Mines

U. S. Civil Service Commission announces an examination for laboratory assistants to fill vacancies in the Bureau of Mines, Department of the Interior, for duty at Pittsburgh, Pa., or elsewhere, at $1320 to $1500 (senior grade), $1200 to $1320 (intermediate grade), $1080 to $1200 (junior grade), and vacancies in positions requiring similar qualifications, at these or higher or lower salaries. The entrance salary within the range stated for a grade will depend upon the qualifications of the appointee as shown in the examination and the duty to which assigned. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. In the absence of further notice, applications for this examination will be received by the Commission at Washington, D. C., until the hour of closing business on April 5, 1921. If sufficient eligibles are obtained, the receipt of applications may be closed before that date, of which due notice will be given. For any grade, applicants must have graduated from a 4 yr. high-school course or have had equivalent education, in addition to special training and experience and must have reached their eighteenth but not their fortieth birthday on the date of making oath to the application. Age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating the title of the examination.

When the Snow is Deep

It is said "a touch of nature makes the whole world kin"; therefore I believe that all will pardon me for intruding this little item into an engineering journal.

When the snow is deep, our birds cannot find any food. Brush the snow off a spot on your window ledge, or on the ground. Drop some bread crumbs, seeds, or anything the little joy balls will eat, then go your way happier. You will be—and so will the little fellows.

J. B. Dillon.

A Backwoods Start

PIRATICAL ADVENTURE STIMULATES AMBITION AND SERVES AS A STARTING POINT FOR CAREER

BACK in 1885 I was a youngster boasting 13 years of life experience and, of course, sure that I could do anything if I only had the chance. I am an engineer and naturally go about any job in an engineer's fashion by collecting my materials and then starting the job. So you who read this will find that my story telling will be more after the way of building an engine than of fine sentences and high sounding words such as a writing man would give you.

Being the story of my start, naturally the most prominent character will be myself, but of that there is not much to tell. I was a usual country boy of the woods, with no special taste for books, making a showing in school that was neither a credit to myself nor to the teacher, even in such few branches as the little log shack and the six months term afforded. Naturally, I knew the woods, was used to doing things for myself and to making my own things such as fish poles, traps, bows and sleds; I could shoot, row, paddle and find my way anywhere, but I wanted most of all to tinker with machinery, and there was not much available except a few wagons and the sawmill of which my father was engineer, and, of course, he wouldn't let me touch any part of his plant. He tried to get me to help with the firing, but I wanted to run the engine, and was sure that I could do it as well as he.

My spare time, if you could call it that when I had all the time that there was to spare, was mostly spent with the Indians who were on the reservation nearby, my favorite companion being a half-breed boy a little older than I who had a sail boat on Lake Michigan, a canoe on the little lake about a mile from the camp, knew all the best places to fish, would do absolutely no work, and was reputed to be wild, a reputation that he cultivated carefully by boasting to me and the other boys of his escapades, though the wildest thing that I ever knew of his doing was catching fish out of season and launch stealing, of which more later. My parents objected to my running with him for fear that I would get wild too, but to tell the truth I fear that I was quite as wild as he and that most of the ideas of the things which the older folks called outrageous pranks came from me rather than from him. I did not want to pose as a wild leader, however, so, as he did, he got the credit; and those who may have known or suspected the truth kept quiet about it out of respect for father; so my folks never suspected me, though they did not like my idling with the Indians.

My scamp companion was known in the camp as Hi Lo, and the name fitted. He was 6 ft. 3 in. tall, which accounted for the Hi, straight, strong and active when he chose to be. And he was certainly Lo, the poor Indian, with loud pedal on the *poor;* ragged, dirty and lazy. The hardest work he did was fishing, and his favorite occupations boasting and gambling with pennies when by accident he happened to get hold of a few.

One of the chief excitements of the camp was playing hide and seek for a "steam launch," so-called, which was owned by one of the men known as Heavy Simplewate. It was the only power boat on the little lake and river, and whenever anybody wanted to go down the lake or up the river to fish, they liked to take the "launch." But Heavy didn't care to loan it and devised various hiding places and methods of "locking" the boat to discourage borrowers. There was never any question of asking the loan of the boat, as it was understood that if a man could find the craft and get her going it was community ethics for him to take it. In most backwoods camps, boats not in use are common property, the user making proper return for use to the owner after he comes back. This saves time in hunting up the owner, who may be off on a long trip, and in case of emergency is really necessary; but Heavy, though not willing to run counter to custom to the extent of forbidding the use of his boat, did not like the custom and took the hide and seek method of discouraging it. It was always an exciting game if anybody wanted the "steamer" to use, first to locate her whereabouts and second to discover in what way Heavy had tried to put her out of commission and to devise a means to get her going again. The boys were barred from this game, for it was tradition that she was dangerous, both because of her condition and of the machinery which she contained.

As the story centers about this craft, "The Beauty Belle," as Heavy had named her, it will be well to look her over. She was a flat bottomed tub, some 25 ft. long by 5 ft. beam with straight sides and stern and a tip-tilted nose—a rectangular box with the lid off and beveled at the front end at 45 deg. To serve as keel and stiffen her, a 4 by 4 timber had been put down the center at the bottom, but this did not add specially to her seaworthiness. The steam plant was unique, even for a backwoods boat. The boiler was a wood-burning vertical of usual construction, 20 in. by 4 ft., but the stack was a piece of stove pipe laid back horizontal to beyond the stern of the boat, as Heavy didn't like to "breathe smoke 'cept what I make myself." Feed water was pumped direct from the lake by a hand-operated crosshead pump through a check valve and stop valve; the safety valve was of ball and lever type and the usual gage glass, trycocks, steam and blowoff valves were there.

Piping was short and direct in conformance to the best practice. It was a single horizontal run from the outlet of the upper cross on the gage glass connection to the steam chest of the vertical engine, with a stop valve and a union. There was no steam gage; the union was on the boiler side of the stop valve, and when she got pressure enough to "blow strong around the jint," there was pressure enough to start the engine. When the safety valve blew off, it was "time to moderate thet fire."

The engine was a single cylinder center crank slide valve with flywheels on each end of the shaft, set on

a crib frame of four by four timbers which were bolted to the keel. She never ran hot, for there was at least 1/16 in. play in crosshead, crankpin and main bearings, but under way she sang a peculiar song of her own. On the up stroke she took up the lost motion in sequence, crosshead, crankpin, main bearings—chuck-a-luck; then the stem around the piston rod—szzzz; on the top center the crosshead and crankpin usually beat the shaft by a fraction of a second in getting to bearing—kerbang. On the down stroke there was silence except for the steady obligato of the hiss through the union and the creaking of the timbers and planking of "Beauty Belle."

In the transmission and propulsion Heavy had produced a real achievement. Somewhere he had acquired the insides from a double-wheel exhauster fan, and with the help of the blacksmith had concocted two wood pulleys which were clamped to the shaft, one opposite each flywheel of the engine. One pulley was for forward drive by means of an open belt; the other for backing with a crossed belt; to reverse, you threw off one belt and put on the other. The engine was nonreversible. The old fan bearings had been mounted one on each side of the boat by bolting pieces of 6 by 6 to the side planking and running a piece of 2 by 6 at each end of the pillow block down to the bottom planking; it gave the effect of an improvised post hanger.

As may be imagined, the engine was not mounted to stand high speed, nor was the pulley ratio great, so that with the lost motion there was a distinct pause of the paddles at the end of each stroke. Heavy's statement that "When Beauty Belle gets her fodder right she jest walks away down the lake," was literally true; one step and then another. She was steered by means of a plank held between two, two by four sticks which were bolted to the stern plank, and did not answer the helm particularly well, especially in a wind; but that was not of so much consequence, as nobody was foolhardy enough to venture out in her in heavy weather.

It was exciting to ride in her on a calm day. The engine had plenty of power, the paddle wheels were large, and so long as the boiler was stoked vigorously and the hand pump kept steadily going she would make surprising speed. All the boys itched to get a chance to run her, but either none of them had dared to break over the public ban or none had been able to get her going after Heavy had dislocated her machinery.

Heavy himself is worth knowing. Like most country nicknames, his fitted. It was a mystery how the Beauty carried both him and the machinery without breaking in two amidships, for he was of the Mexican athlete type, a champion at table and in the story-telling circle which gathered in the camp store of evenings. He could catch more and bigger fish—by mouth—than anybody else, but he couldn't cut wood, carry water or hoe corn because his "chist pains got so inflictin' whensumever he bent stoopin'." For occupation he "druv mail," one trip a day, from camp to the station 3 mi. below, and for avocation he tinkered on "Beauty Belle" three days a week to keep her in "racin' form" so that he could fish the other three days. Sunday he devoted zealously to "restin' up for a hard week." He was good-natured except when somebody got away with the boat, and then his grouch was more that he had been outwitted than because the boat had been used.

One bright July day Hi Lo and I decided that it was necessary that we have some fish, and the kind that could be caught near camp would not do at all; we wanted to go down the lake where the big black bass were. We got poles, lines and bait and went down to the canoe, but the sun was hot and it was a good 3 mi. to the bass grounds. There was where my tempter spoke.

"Let's hunt up Belle," was my suggestion. "Too much hot to run," answered Hi. "Well, let's find her anyway. You steer and I'll run her," I replied, and Hi grunted assent.

There were only some dozen places where the Beauty could be tied up near camp and we soon found her, fortunately for us, well out of sight of the camp and the mill. Now, Heavy had been especially careless in putting Belle together at the last tinkering, and had left off the safety valve ball and had overlooked the check valve bonnet and valve. Even Hi's Indian instinct could not locate them, so I had to devise a substitute. The ball was easy, for a stone in a pail soon adorned the lever, but the check valve was different. I tried a wooden plug, but as the pump was single-acting and its discharge valve not very tight, we could get but little water into the boiler. Not to be balked, I took off the safety valve, got a pail and, with Lo dipping and passing up to me on top of the boiler, we soon had two gages in the glass.

We put back the safety valve, started the fire and were merrily on our way without being discovered.

All went well until I discovered that water in a boiler does not last forever. In about 20 min. and after we had gone a mile or so, I looked at the gage glass, and no water. Why I had the sense I do not know, but I pulled the fire and ran the engine as long as it would turn. Then we had to take off the safety valve again and start the Indian-pail feed pump. We fired up and ran on again until fuel got low, but we ran as near shore as we could and brought off a supply of dead wood which lasted well until we got to the fishing ground after one more stop to man the pump.

After a couple of hours fishing in which we caught a string of good-sized ones, we considered the question of getting home; but Hi rebelled at the thought of acting as human hand pump and voiced his conclusion "Too much work. Walk."

Three miles walk was nothing, as it was in the cool of twilight, but what to do with the Beauty was another matter. If we left her it would surely be discovered that we had taken her, and it was more than likely that it had been discovered anyway. If we took her back, all right; it might be regarded as a good joke on Heavy; but if we didn't, both he and my folks could certainly demand vengeance. I had to find some way to get her home. But how could I get the water in if Lo wouldn't help?

By various trying I finally discovered that the disc on the feed stop valve was loose on the stem. It was set with boiler pressure on top of the disc so that it

would not let water out of the boiler, even when the stem was unscrewed a full turn, but the disc would lift enough to let some water through when the pump was worked vigorously. So I bargained with Hi that if he would help fill up once more I would keep the boiler full until we got back. We gathered a big lot of wood so as not to have to "coal ship" on the return trip, filled up the boiler and started.

I literally worked my passage home. By keeping at the pump until I had to fire, then closing the feed valve and firing up, then getting back to pumping, I could just about keep things going. Once I had to stop the engine while I pumped the boiler up and we drifted back a quarter of a mile while I was doing it. But we made our home port in about 2 hr. and found Heavy raging on the shore.

"Ye meazly pizen bugs! What ye mean stealin' off th' Beauty Belle? I thought nobody couldn't get her goin' the way I left her 'thout any steam anchor an' her pump spout wide open. Say, tell me how ye run 'er and I'll let ye off an' not tell yer dad."

I was quite willing to bargain on that basis and told him just how we had operated. He studied a while, and then said, "Hown' blazes ken I fix 'er so'st some other meddlin' redskin can't tote 'er off any time he's too ornery to do a leetle paddlin'?"

Then I studied for a while and suggested that he take off the top half of one paddle shaft bearing and take out the steam throttle bonnet and valve, for I couldn't figure how I or anybody else could run her in that shape.

Hi Lo had disappeared as soon as the boat touched shore, but I had taken care to hang on to my part of the fish. I had a peace offering for the family and something to explain my late coming, for everybody would know that those bass must have come from down the lake. But Hi's desertion and refusal to help work the pump had opened my eyes, and I kept thinking as I walked home what would have happened if that valve disc hadn't been loose.

I ran, of course, the full catechism as to where I had been, what I had done, and whom I was with, all of which I told, but not a word about the boat. Secretly I thought that I had been an engineer as well as dad and I questioned whether he could have got Beauty home. I didn't want to hurt his feelings, however, by suggesting it, and I had some misgivings as to what might be the result to my feelings if he found out what I had done. But the thrill of that running machinery was in my blood and I said later in the evening, "Dad, I want to go to firing in the mill. How soon would I be able to learn to run the engine?"

Dad looked me over carefully but I kept a serious face and he finally said, "Well, son, I'm glad you've decided to steady up and start to learn a real job. You get so you can handle the boiler right and then we'll see about the engine."

I have not known what became of my Indian chum, whether he went on to study navigation and became a sea captain or not; but I kept on with father, studied his books and worked with him and other helpful engineers until I now have a chief engineer's license of my own and the reputation of being an engineer of ability and good judgment.

The American Mining Congress

By J. B. Dillon

BORN 23 yr. since in Denver, Colorado, was the American Mining Congress, and proud of her record, she held her twenty-third convocation in her native city.

The principal requirements for the welfare of the mining industry and our nation is that the gold mining industry is better stabilized and appreciated and that is the reason why the McFadden bill was drawn up and every honest effort will be made to have it become a law.

Should the McFadden bill be defeated, it is suggested that the gold producers of the Unitetd States and Alaska organize for the following purposes:

First—To deposit the gold produced by them in the mint and demand coined gold in exchange therefor.

Second—In the case of gold ore sold through smelting companies to arrange for the equivalent of the gold contained to be deposited in the mint, withdrawn as coin by the smelting company and delivered to the producer in settlement for the ore.

Third—To place such gold in circulation by using it in liquidation of payrolls, in payment of supplies, etc.

Fourth—To arrange with local bankers in gold producing localities to furnish gold in all withdrawals to an amount equivalent to deposits of gold made locally by them.

Fifth—To provide for cases where local banks are unwilling to adopt this course by the organization of a central gold bank with branches in various mining camps organized under the state banking laws.

Sixth—To conduct a concerted propaganda in favor of the use of gold and silver, or gold and silver certificates in preference to federal reserve notes.

President-elect Warren G. Harding, unable to attend, although invited, wrote: "With wisdom and deliberation such as we hope to secure by dint of enlisting the aid of such expert authorities as your own organization represents, I believe we shall place our country and its industries once more on the high road of prosperity and success. To that end you may be assured that every energy and effort of the new administration will be directed."

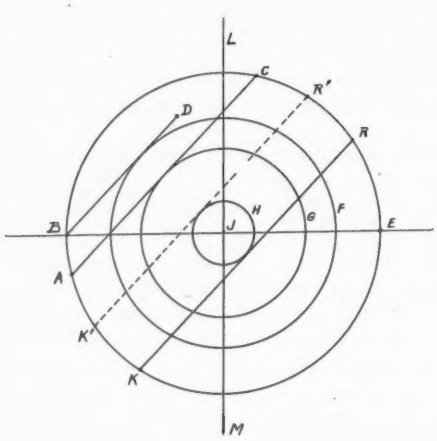
Every available inch of space at the Albany Hotel was taken up with booths, manufacturers from all principal cities exhibiting articles useful to the mining industry, while on the outside on one of the principal streets of the city a shed was erected giving about 20,000 sq. ft. of floor space and that was turned into "Machinery Hall," all of the latest and most approved machinery being shown in operation. W. J. Loring, of San Francisco, was elected president and as Atlantic City, Chicago and Pittsburgh have their hats in the ring for the next Congress, the matter will be decided later by the board of directors.

You Tell 'Em

As the cylinder said to the piston, "You tell 'em the trouble, old flathead; I'm bored."

S de Valve Diagram

LATELY I have had occasion to use slide valve diagrams and the enclosed diagram is one which I have developed for my own use. The construction of this diagram is exactly the same as the ordinary Sweet (or Rouleaux) diagram only the method of representing the different variables is a little different. It is in such a form that it ought to be easy to be memorized with the result that if the diagram itself is lost it could easily be constructed again from memory.



BE & LM are the horizontal and vertical axes of the diagram.
The radius of outer circle is equal to the ECCENTRIC THROW.
The radius of circle (F) is equal to the displacement of the valve from its central position when the crank is on dead center, i.e., its radius equals STEAM LAP + LEAD.
The radius of circle (G) is equal to the STEAM LAP.
The radius of circle (H) is equal to the EXHAUST LAP
Angle DBE is equal to the ANGLE OF ADVANCE.
The lines BD, AC, K'R', and ER are all parallel to each other and each line is tangent to one of the circles as shown in the drawing.
A is the point of ADMISSION.
C is the point of CUT-OFF.
R is the point of RELEASE when EXHAUST LAP is POSITIVE.
R'is the point of RELEASE when EXHAUST LAP is NEGATIVE.
K is the point of COMPRESSION when EXHAUST LAP is POSITIVE.
K'is the point of COMPRESSION when EXHAUST LAP is NEGATIVE.

EASILY MEMORIZED VALVE DIAGRAM

I have thought that such a diagram might be of interest to other people so I am sending it to you to publish if you so desire. Anyone who can read drawings could use this diagram as a visual table to replace the table given in your book, "Engine and Boiler Room Lore," as he could easily see from it what effect a changing of the steam lap, exhaust lap, lead, or angle of advance would have upon the four valve events.

The designer can use this diagram to solve any problem that can be solved by the Bilgram diagram, even including those problems where the valve travel is unknown.

Of course the ordinary correction for angularity of eccentric rod should be made in exactly the same way as is done on other diagrams if such a refinement is thought to be desirable. HAROLD W. SIBERT.

Signals for Water Purifying System

RECENTLY the writer was called upon to place some signaling bells upon a water purifying system which consisted of two overhead settling tanks and one filtering tank below, the object being to have one bell which would ring when either settling tank was full and the other bell to ring when either settling tank was empty.

The material provided was four cells dry battery, two bells, three single-pole, single-throw baby knife switches, three float switches and a sufficient quantity of weather-proof No. 19 telephone conductor; the object of using

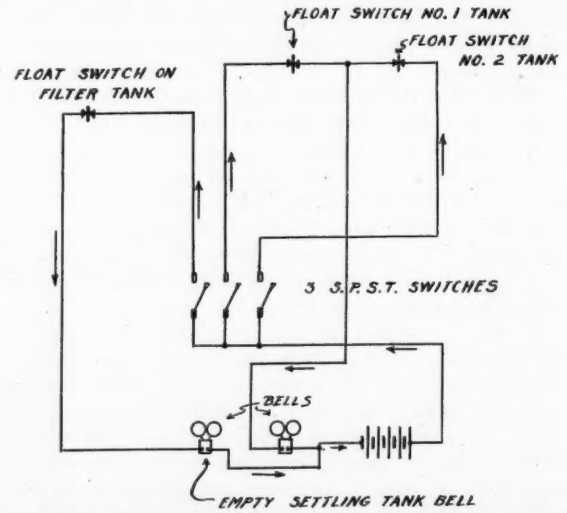


DIAGRAM OF CONNECTIONS FOR WATER PURIFYING SYSTEM

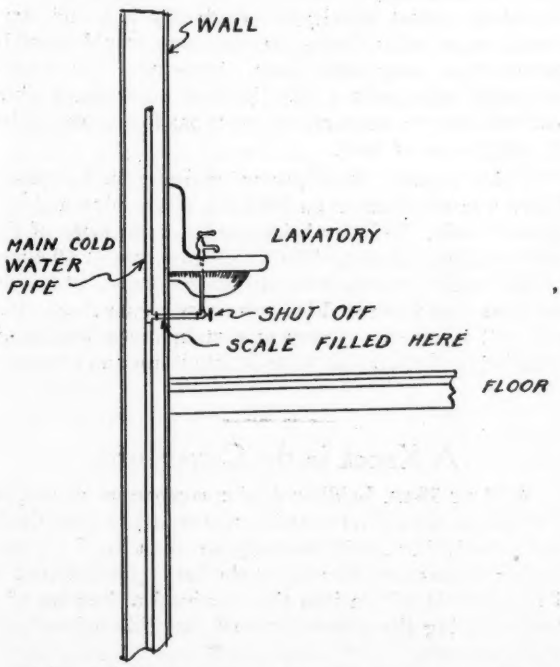
weather-proof telephone conductor was that practically all of the wiring was outside. A float switch was placed on the top of each settling tank and so set that when the water rose within 2 in. of the top of the tank, the float would rise and close the switch. The other float switch was placed upon the top of filtering tank and was of such a type that when the water in the filtering tank settled a certain amount, the float dropped down closing switch.

As a matter of convenience, the three single-pole, single-throw switches were placed on the side of the filtering tank. As another matter of convenience, the bells were placed in the engine room and the battery, because of the better location, was placed close to the bells. Then the wiring was done as illustrated in the

accompanying sketch; that is the four cells of battery are connected in series so as to get the benefit of their combined voltage, then one terminal of the battery connects the lower terminals of all three single-pole, single-throw switches. Two of these switches have been numbered 1 and 2 respectively. The top terminal of No. 1 switch connects with one terminal of the float switch on top of No. 1 settling tank, while the top terminal of No. 2 switch connects with one terminal of the float switch on top of No. 2 settling tank. The other terminals of these two float switches are connected together by one wire which in turn connects with one terminal of one of the bells in the engine room. The other terminal of this bell connects with the opposite side of the battery to which the three single-pole switches are connected. The upper terminal of the remaining single-pole switch connects with one terminal of the float switch on the filtering tank. The other terminal of this float switch connecting with one terminal of remaining bell in engine room. The other terminal of this empty settling tank bell is connected with the opposite side of the battery which connects with the single-pole, single-throw switches. J. C. K.

Clogged Water Piping

An article in the Nov. 15 issue, page 1098, entitled "Air in Water System" brings to my mind an experience I had. It was in a hotel of 115 rooms, five floors



WATER PIPING SHOWING LOCATION OF SCALED PIPE

high. On the fourth floor, the cold water in one room ran slow. On investigation, I found all necessary pipe lines and valves to be opened and as I thought to be all right; but I never dreamed of scale causing so much trouble.

In the accompanying sketch, you can see I found the short pipe between shutoff and wall main nearly plugged full of hard red scale. It is a ½-in. pipe. I used a ¼-in. copper rod I found to loosen the scale, but first I shut the water off for that particular main. The shutoff and bib had both to be ground in.

In a room constantly in use, city water pressure at 40 lb. was used. How did this particular piece of pipe plug when no others did? R. G. Summers.

City License

In the Dec. 15 issue I read Mr. Ray's views regarding license. Mr. Ray is correct; the state does need a license law. I would like, however, to see a national law or at least universal agreements between states. In the city to which he refers I think you have to be a resident of the city for 5 yr., and have two people to sign your application and you must make oath to the statements. Suppose that a person quits engineering, say for 10 yr. and then he wants to go back to the profession, and in a different city, or goes to a place where he has never been, it is hard to get his application signed, as nobody knows him.

I should think that if he makes his statements on his application and goes under oath, it would be sufficient. To think you have to have a position before you take an examination is wrong; and I cannot see why it is required to give the size and horsepower of a plant.

I will say if Mr. Ray ever comes to Ohio he will have no trouble in taking an engineer's examination and if he gets his percentage he will obtain a license.

F. W. Schneider.

Purging Ammonia Condensers

Frequently (too frequently, in fact) one is met by the belief that a mixture of gases if allowed to stand for a while undisturbed, will stratify or separate into layers according to the differences in their specific gravities—the heaviest at the bottom and the lightest at the top after the manner of some liquids. A moment's consideration will convince one that if this were to become an established fact, living things as now constituted would soon perish.

The atmosphere is composed of a mixture of nitrogen, oxygen, argon, carbon-dioxide and traces of other gases, their respective volumes being in the order named. If these were stratified, it would be in the order of their specific gravities and there would be a layer of carbon-dioxide next to the ground, above which would be a layer of argon, then a layer of oxygen surmounted by a layer of nitrogen. A man's chances of surviving such a condition can easily be imagined!

In the Dec. 1 issue of Power Plant Engineering, Mr. Solomon, discussing the purging of ammonia condensers, expresses the belief that the gases, air and ammonia, will separate by virtue of the difference in their specific gravities. If this were the case, the purging of condensers would present no problem and the loss of ammonia from this cause would be slight. The facts of the case are, however, that the gases exist as a more or less perfect mixture due to the operation of diffusion as explained in the kinetic theory of gases, and the selective purging of gases will be found not a simple matter.

Mr. Solomon illustrates by means of a diagram how he would purge an ammonia condenser, taking advan-

tage of the fancied stratification of the component gases. Imagine a pipe filled with gases discharged from the compressor; the valves at the inlet and discharge of the pipe are closed and water is allowed to flow over it until the contained ammonia is condensed. According to Mr. Solomon, the remaining gases (air and hydrocarbons) may be easily blown out.

If the condensing of the ammonia and the cooling of the non-condensible gases has not reduced the pressure below atmosphere, then there will be some discharge on opening the valve, which discharge will cease upon the pressure reaching that of the atmosphere. Any further discharge must be effected by opening the valve communicating with the compressor. The net result is the same as obtained with the purge valve in the customary location.

It has been proposed to place a valve in the lower pipe of the condenser coil at the end opposite to the valve at the liquid header. This arrangement provides a chamber into which the liquid ammonia may be trapped. The coil is then manipulated in the usual manner for purging. The new valve is now closed, isolating the trapped ammonia from the coil. The coil is now placed in communication with an air pump and exhausted to the capacity of the pump. Communication with the pump is now closed and the valve at the hot gas header is opened slowly, allowing the gas to fill the coil. This method of purging would save the ammonia usually lost in purging, but would probably cost more than the customary method when it is carefully done.

C. O. SANDSTROM.

Getting a Vacuum

WE HAVE a 1000-hp. tandem Hughes & Philips Corliss engine exhausting into a barometric condenser and the other night as we were starting up for a week's run, the assistant engineer, on getting the signal, opened the throttle and, so as to get running condensing, pulled down on the wire rope which closes the atmospheric valve. The pump which furnishes the water for the condenser is a single-stage centrifugal, belt-driven from the line shaft.

The assistant engineer, who is a rather heavy man, pulled down with all his weight on the wire rope, fully expecting to see the needle on the vacuum gage come around as usual. As no evidences of vacuum appeared, however, he brought the steam pressure down, released his hold on the rope and shut down.

The belt was found to be all right on the pump. So he tried it again, steam again being up, but with no better results.

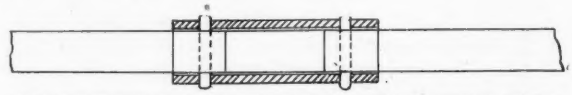
A valve on the centrifugal was opened and water coming out of it only made things more puzzling. The chief took a try at it, but without success.

All sorts of things were thought of and a complete inspection of the condenser and piping was made; but it seemed all right. Finally the writer took a hand; we got the vacuum first sendoff. The only explanation we can think of now is that the assistant who first started, put so much back pressure on account of his weight on the rope and valve that the water was blown back down the pump discharge pipe and the writer was so slow getting the engine up to speed before pulling on the valve that the water had got to the cone on the injector first.

W. S. HALL

Emergency Safety Coupling

THE FINISHED diameter of a 2-in. line shaft is slightly less than 2 in. The internal diameter of 2-in. extra heavy steam pipe is slightly less than 2 in. These conditions, being known, were made to serve and help a man out of a difficulty.



SHAFT COUPLING MADE OF EXTRA HEAVY STEAM PIPE

Resetting some machines made it necessary to rehang some of the shafting. At one point, the newly placed shaft proved about 18 in. short. The two pieces of shafting were taken from the hangers, a piece of extra heavy steam pipe was cut 3 ft. 6 in. long, the ends cleaned internally and driven 12 in. over the ends of the shafts as shown in the sketch. After testing for straightness, two holes were drilled through the pipe and shaft ends and steel pins driven in. I have been told that this simple emergency coupling gave excellent satisfaction.

J. E. JAMES.

What Caused the Pound?

THE FOLLOWING engine trouble may be old news to some of the readers. It was new to me when it occurred. The engine was in a small plant and direct-current connected to a d. c. generator. For days at a time it would run along almost noiselessly. Suddenly it would start pounding so badly that a first-day man would possibly make a "get away safe" dash. Sometimes this pounding would start with a light load, at other times when load was heavy; sometimes it never made a cheep under all conditions of load.

Unfortunately, there was no indicator in the plant. There was a separator on both the steam pipe and the exhaust main, the latter being used to clear some of the oil out of the exhaust. The water level was at all times at the center trycock level in the column. Ultimately the pounding was cured by using new piston rings. But why did it act so contrary at certain times, the conditions being the same as when it acted quiet and respectable?

A Knock in the Compressor

A 14 BY 18-IN. Laidlaw duplex compressor developed a knock in the cylinder and I was called to investigate and remedy it. As it was only on one side, I thought the piston was striking against the back cylinder head so I screwed the piston into the crosshead a fraction of a turn to bring the piston forward, but this did not improve matters.

In opening the drain cocks, small flakes of brass came out, so I judged at once that something had got loose inside and was being pounded to pieces and the head had to be taken off. The compressed air being needed nearly all the time, so as not to hang up, the connecting rod of the knocking side was disconnected from the crankpin and the other side was kept running. In taking off the head, I found that a bronze valve seat had worn down so much that it had fallen in the cylinder, a ring about 3 in. in diameter and ½ in. thick. The

piston was also taken off to see if the ring was broken, but everything was in good shape. Some luck that it had been only some knocking! Many a compressor would have been wrecked by such a mishap.

CHAS. LABBE.

An Engineer's Influence

SOME TIME ago, there appeared in your magazine an article entitled, "Arthur and I," which interested me greatly and I know that it is helpful to young men who are just starting out in steam engineering to have some man of experience who will take enough interest in them to help them in the right way.

I have in mind a man who has been in the business for about 19 yr. and I have heard him say several times that he would have liked to have known and worked for such a man as Arthur in his younger days.

It was strange just how his case worked out, for he found in the first plant where he hired as a fireman that they wished to have him look after the engine for part of the time and so after a very short time he used to operate a small electric light plant for the latter part of the night. Of course he had been interested in steam machinery for years before he left school, but he had had almost no actual experience. He was very careful, however, and thus he did very well as an operator and he looked forward to the time when he could get a job as a fireman under an engineer such as "Arthur" and get some points that would help him.

He then hired out as a fireman in a small mill plant, and while the engineer there did all that he could to help him, he was not a man of very great experience and thus we see the fireman doing all that he could in the operation of the plant and many things that were not expected of him. Above all, he surpassed the other firemen who had been there before him in his ability to leave liquor alone. Because of this, the management considered him one of the best that they had ever seen and before he had been there a year, the engineer had a better offer and they offered the fireman the vacant position. He was reluctant at first to assume the responsibility, but they insisted, and thus in less than 2 yr. after he commenced the business, when he was but 22 yr. old, he was in charge of three boilers and a 16 by 48-in. Corliss engine.

By most predictions, he should have slumped on the job or done something that would cause some accident; but his caution and care kept him safe and he did better than some of more experience had before him; and yet as he said, "I have to try so many things out without any previous advice on how to begin the work."

Because his employers broke their agreement with him, he left that job and for over a year he was a fireman again, in places where there was little appreciation of his work. There were times when he was somewhat discouraged. He finally gave up his job because he did not like the methods of the company and right on the heels of this, he had an opportunity as chief in a large power station in the country. He went, with many misgivings for the future, but for nearly 5 yr. he made a success of the position, still regretting, however, the lack of an adviser like "Arthur."

It seems strange to me why more things did not happen in that plant, for every day we read of serious accidents in large plants, in charge of the best of engineers, and I have observed in the career of this man that he seems to have little trouble in the plants of which he has charge. Why it is, I cannot understand, unless he remembers the fundamentals and uses common sense, for in almost every plant that he has left, there has been considerable trouble afterward and in some cases the cost of the damage has been great enough to have paid his salary for some years.

In spite of all this, I know that he always has wished that he could work in a modern plant under one of those men to whom the machinery is as simple as a wheelbarrow is to the average man. When we come to look about us, we find many who, like my acquaintance, lack knowledge, but who, unlike him, do not know that they are lacking in the necessary experience and often start something that they are unable to finish.

I can readily understand the regret and appreciation felt for "Arthur" by the writer of the article in view of what my friend has been through and though he is today a step above the engineering business, he is always glad to talk with men of experience and he is always ready to learn from his subordinates. As a result, he is well liked and none of his men can ever say that any suggestion that they make fails to receive attention and a trial if proved worthy of it.

If the young men of today who wish to follow the trade, will try to find an "Arthur" and tie to him if he will help them, and not mind the pay or hours for a time, it will certainly be of great benefit to them. Then when they get charge of their first plant, they will have some idea what to do in an emergency.

GEORGE H. KIMBALL.

To Be Sure that Ammonia Drum is Empty

THE ARTICLE in the Dec. 15 issue, page, 1192, by Mr. Schaphorst, regarding ammonia drums is a new one on me and I must say a good one. The way I always tell an empty from a full drum is to lay the drum on a level floor and grasp it at the end with both hands, give it a good shake sidewise and let go. If it is empty, it will stop. If there is any liquid in it, the drum will wiggle, due to the motion of the liquid in the drum.

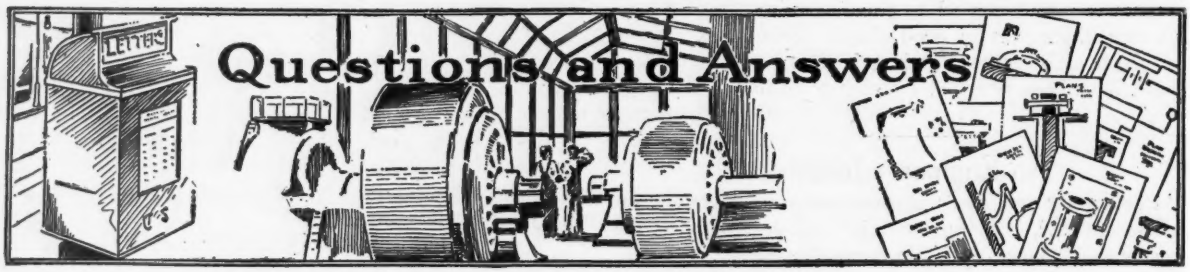
R. G. SUMMERS.

Signaled from Afar

STOPPING at LaSalle, Colo., about 30 mi. east of Denver, getting out of the cab and oiling his engine, returning to his seat and waiting for the conductor's signal to continue homeward, George Hockenberger, 61 yr. of age, the oldest and one of the most lovable engineers on the Union Pacific Railway, died with his hand upon the throttle.

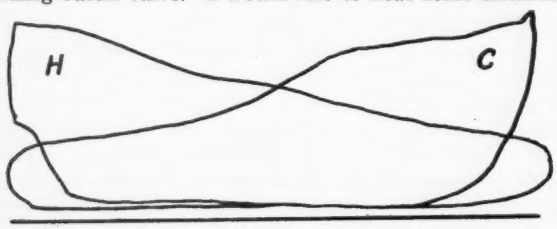
WHAT THE WORKER (in the United States) wants is an open path ahead. He may not reach the end, but he wants to know it is there. He knows that the prize isn't to everyone, but he wants a chance at it.—Whiting Williams in The Nation's Business.

IF YOU HAVE half an hour to spare, don't spend it with somebody who hasn't.—Forbes Magazine.



What Suggestions Have You to Offer?

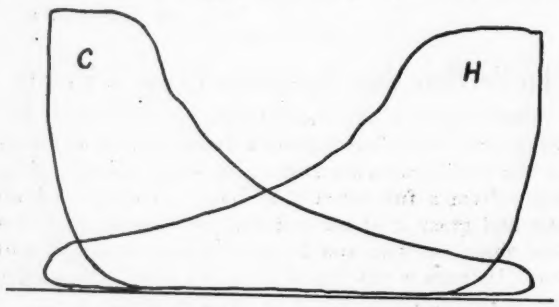
THE ACCOMPANYING CARDS were taken from a 14 by 22-in. engine running at 74 r.p.m. and equipped with a riding cutoff valve. I would like to hear some criticism



INDICATOR CARD FROM AN ENGINE EQUIPPED WITH A RIDING CUT-OFF VALVE

and suggestions for improvements from readers of Power Plant Engineering. A. S.

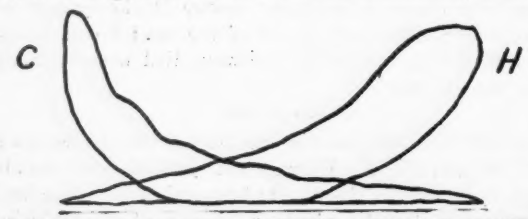
HOW CAN I improve the accompanying card, taken on a Murray-Corliss 18½ by 30-in. engine., direct-connected



INDICATOR CARD FROM A MURRAY-CORLISS ENGINE

to a 150-kw. d.c. generator? Boiler pressure is 115 lb.; r.p.m., 125. H. A. C.

THE ACCOMPANYING CARD was taken from a Skinner automatic 11 by 12-in. engine running at 230 r.p.m. on 80 lb. boiler pressure after I had made some adjustments,



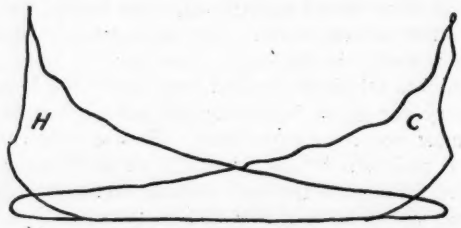
INDICATOR CARD FROM A SKINNER AUTOMATIC ENGINE

but I am not satisfied with the results and would appreciate further information as to how I might better conditions.

I took the cover off and blocked the governor out within an inch of its extreme travel and then centered the valve travel, which resulted in the card shown.

L. C. T.

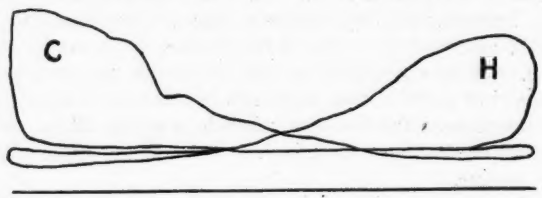
THE INDICATOR CARD shown herewith was taken from a cross-compound Buckeye engine on the high-pressure cylinder. Boiler pressure, 145 lb.; receiver pressure, 15 lb.; r.p.m., 150.

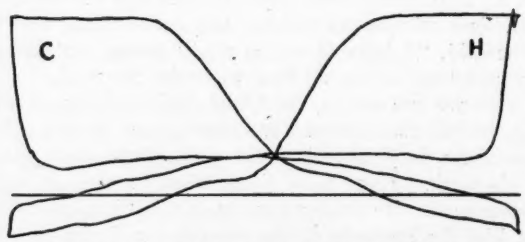


INDICATOR CARD FROM A BUCKEYE CROSS-COMPOUND ENGINE

I would appreciate having the opinion of your readers as to how I can make improvements. C. R. D.

HEREWITH IS a set of indicator cards from a Ball Wood Corliss cross-compound non-condensing engine of the non-releasing gear type. The size is 20 by 34 by 18 in., the speed is 150 r.p.m., steam pressure is 120 lb.





CARDS FROM A BALL WOOD CORLISS CROSS-COMPOUND ENGINE

What do you think is wrong with them, and how can I remedy it? T. J. M.

WE WOULD LIKE the criticism of your readers on the card shown herewith. It is taken from an Ames Una-

INDICATOR DIAGRAM FROM AN AMES UNAFLOW ENGINE

flow engine running at 200 r.p.m. on steam, 195 lb. pressure and 100 deg. superheat and 19-in. vacuum.

C. C. N.

Formation of Magnetic Oxide in Boiler

CORROSION HAS been going on in a set of boilers in a certain plant for some time. Water used in boilers is condensate from surface condenser. Make-up water is taken from cistern or spray pond. This water in the spray pond is water that has been treated with a lime-soda ash treatment. The water is used for circulating water through the surface condenser, and the formation of magnetic oxide goes merrily on regardless of whether there is scale or no scale. The places that are affected worst are the rivet heads and just on the inside of the tubes for from 2 to 4 in. from the ends. Has any other reader had such experience, and what steps were taken to prevent such action? J. E. S.

Feed-Water Heater

IN THE DEC. 1 ISSUE on page 1149, under "Feed-Water Heater," appears the question, "What is the best method of feeding water to a boiler: Pumps or direct return steam traps?"

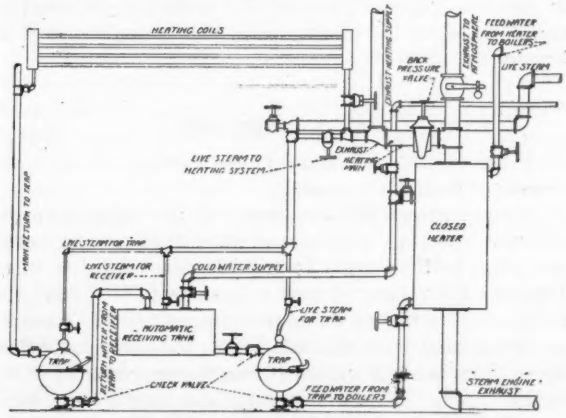


FIG. 1. METHOD OF FEEDING WATER TO A BOILER

If I had a system of any size, I would never put in a gravity return. For a fair-sized installation I would take an old trap, dismantle it and use it for a receiving tank, placing it so that all condensate from the heating coils would flow into it by gravity. This I would connect with a trap about 4 ft. above the boiler and then apply pressure on the tank to force the water to the trap.

For a larger installation, I should prefer a vacuum pump, automatic receiver and feed pump. Tap all returns to the vacuum pump which will make delivery to the automatic receiver, then tap the feed pump to the receiver which would have a float control. This system is shown in detail in Fig. 1.

In the Dec. 15 issue, on page 1199, there is a question under the heading, "Feed-Water Heater." Figure 2 illustrates the way I would make the installation. With this system, L. C. T. can heat his feed water to 200 deg. In his system, without engine exhaust to the heater, I fail to see where he gets his hot water unless it comes from a heating system. His returns will prob-

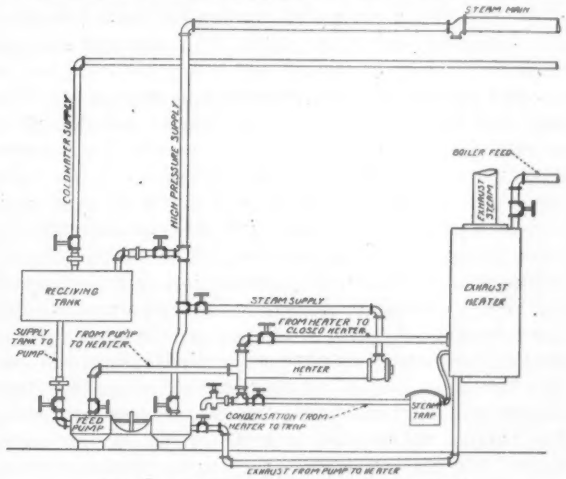


FIG. 2. FEED-WATER HEATING SYSTEM

ably be so hot that his pumps will not handle them. If, however, he allows his water to go through the heater last as I have shown, he will have no trouble in this way.

H. ARMSTRONG.

Four-Valve Engine Cards

REPLYING TO D. R. B., page 1197, Dec. 15 issue, I would say that the indicator diagram is not a bad one for a high-speed engine, with non-release steam valve control. It indicates that the engine is fairly well loaded and possibly a little out of adjustment due to wear of the brasses, pins and adjusting bolts or wedges as the case may be. The compression line is none too great for a high-speed engine. The exhaust line shows no excessive back pressure, compression is late on the crank end. The indicator drum is turning backward slightly ahead of the movement of the piston, which may make the sharp point at admission. Examine the indicator and card for correctness before making any changes. Then go over the valve gear and put in shims or renew any of the worn parts which show an aggregate of more than 1/32 in. wear all the way from the valve to the eccentric strap or pin.

H. M. R. presents a pair of cards from a four-valve high-speed Atlas engine. The fact that a new piston was put in this engine leads me to believe the clearances are not equal. Compression should occur much earlier for an engine running 235 r.p.m. Lack of clearance causes the compression to shoot up in the head end before admission occurs. The admission line falls away, showing no point of cutoff. The clearances may be found by disconnecting the connecting rod and moving the crosshead in toward the cylinder until the piston strikes the head or head end and mark the guide and crosshead. Then move the crosshead out until the pis-

ton strikes the cylinder head on the crank end, make another mark or guide, then connect up the connecting rod again and turn the engine over, stop at each dead center and note the amount of clearance between the mark on the crosshead and the marks made on each end of the guides. If they are not equal, see if they can be equalized by babbiting the brasses, or shimming the brasses in the connecting rod ends. If the piston rod is keyed to the crosshead and is not too long or too short, this shimming up of the brasses should equalize the clearances; but if the piston rod is screwed into the crosshead it may be backed out to lengthen the rod or screwed further into the crosshead to shorten it. You may find the point at which the engine will cut off at extreme load by blocking out the weights in the governor wheel to their extreme position and with the valve chest cover off turn the engine over slowly by hand until the valve just closes the port and then measure the distance the crosshead has traveled on the guide, turn the engine over past the other center, stopping the instant the port is closed by the valve and measure the distance traveled by the crosshead on that end. They should be equalized as near as possible. More compression should be carried on an engine of this speed than the present diagram shows; this can be done by having the exhaust valves close a trifle earlier in the piston stroke. To get best results, the engine should be set to cut off at about one-quarter stroke If it shows one-fifth or less, that would account for failure to carry the load.

R. A. CULTRA.

Change in Receiver Pressure

IN THE ANSWER to the question under the caption "Change in Receiver Pressure" which appeared in your Dec. 1 issue on page 1149, it is stated that if the governor acts on both high and low-pressure valve gears, there will be no change in receiver pressure for a drop in initial pressure.

If the initial pressure drops, such is not the case in actual practice. The receiver pressure will drop every time and, further, if the initial pressure drops low enough, the vacuum will fall off. ALEC MACINTOSH.

Frozen Drop Pipes

IN THE DEC. 15 issue, E. E. asked how to stop the drop pipes from freezing up. C. E. Anderson advises heating the air before it enters the blower or compressor. Now if you have a closed feed-water heater after the blower or compressor it is better, as a blower or compressor will handle more cold air than warm air; the more air you can pass through the water during agitation, the clearer the ice will be.

Heating the air, however, does not remove the moisture as Mr. Anderson stated. Heating the air warm enough will prevent precipitation of moisture in an air pipe, but you must keep the air above the dew point and the more moisture the air contains the higher you must raise the temperature to avoid the dew point. Moisture cannot be removed by heating it.

The maximum amount of moisture that pure air can contain depends only upon its temperature and pressure and has an unvarying value for each condition.

The higher the temperature of air, the greater is the amount of moisture that it can contain.

If, after heating the air and you think that the moisture is gone, put in the brine tank a drop pipe and let it agitate the brine; if you have no moisture the pipe will not freeze up, but if the moisture is not removed you will find in 10 to 20 min. the ⅛ in. pipe will become frozen. FRED W. SCHNEIDER.

I THOROUGHLY AGREE with Mr. Schneider that heating the air will not remove the moisture, but heating the air going to the blowers to a temperature of 75 deg. F. will eliminate the precipitation of moisture and freezing up of the drop pipes in the ice tank.

His last statement will hold true if we agitate the brine in the tank, which is at a temperature of 15 to 18 deg.; but in practice where we agitate the water in the cans until there is only a small core, this does not hold good.

In an ordinary ice plant, using the low-pressure air system for agitating the water, where the temperature of the air in the summer time reaches 90 deg. going to the suction of the blowers, it contains a good deal of moisture—more than the air going to the blowers in the winter time, when the temperature of the air is around 40 or lower; despite this fact, there is no trouble from frozen air pipes in the cans. But as soon as the temperature of the air to blowers goes below 75 deg. or so, the moisture will precipitate and freeze in the drop pipes. This fact can be observed in almost any ice plant using this system.

If your blower has its suction in the engine room and the weather is cold or the temperature below 75 deg., merely heating the air in the engine room to 75 deg. or better will eliminate the precipitation of moisture in the drop pipes. This fact has been demonstrated so many times in ice plants using this system that it is beyond question. C. E. ANDERSON.

Air Compressor

I NEED some information concerning an air compressor. Will you furnish it?

As air enters the air drum of the compressor, it makes a cracking, hammering noise that can be heard any place in the engine room. The noise persists when I change the valves. I have a 3-in., 44-ft. line from the compressor to the air drum containing 2 ells. Changing the connection from the side to the top made no difference. This is a belt driven Gardner compressor running at 250 r.p.m. We have another one here of the same make which is steam driven and which does not make this noise. The drum is 36-in. by 7-in. pressure 100 lb.

L. T.

A. From what you say, we cannot see that the trouble is likely to be in your compressor tank. If this were the case, you would get the same difficulty using either compressor. It would seem that the trouble must be either in the electrically driven compressor or in the line leading from it to the receiver.

The most natural place to look would be in the compressor itself, the noise being transmitted by the pipe line and showing up at the receiver because of its greater resonance. If this is the trouble, the noise will be in unison with the speed of the compressor. If the trouble

is not there, it would most likely be a loose valve somewhere in the discharge line from the compressor to the receiver.

We would like to have you go over the arrangement with these ideas in mind and let us know what you find. If the trouble is not located, we shall be glad to refer it to one of our air compressor experts.

Effect of Power Factor on Steam Consumption

I HAVE a 4000-kw., 1255-amp. (0.80 power factor) alternating-current generator direct connected to a steam turbine. My power factor ranges from 58 to 65 per cent and my current output ranges from 1200 to 1250 amp. at 3100 and 3500 kw.

What I would like to know is how much more steam my turbine is using at 60 and 65 per cent power factor than at 80 per cent power factor. C. H.

A. You have failed to state whether your generator is of the single, two or three phase types, but in checking over the capacity of the machine, it apparently must be of the three-phase type. The power delivered by any three-phase machine may be determined by use of the following formula:

$$P = \sqrt{3}\ E\ I \text{ power factor}$$

Where P is the power, in watts; E is the voltage across any two lines; I is the current flowing through any single line.

According to your figures, E has a value of 2300; I, at full load, has a value of 1255, with a power factor of 0.8. Substituting these values in the above formula, we have:

P = 3994.916 kw., at 80 per cent power factor.

This corresponds closely to the figure given by you; that is, 4000 kw. At unity power factor, and employing the same figures as above, P would be equal to 4993.65 kw.

You evidently desire to know how much more steam will be required by your turbine if the power factor is 60 per cent than when it is at 80 per cent. In order to arrive at any approximate result, it would be necessary to determine, first, the value of the current when the power factor is 60 per cent and the machine is delivering 4000 kw. Again applying the above formula, we have:

$$4{,}000{,}000 = 1.73 \times 2300 \times X \times 0.6.$$

We find that the right-hand side of the equation is equal to 2387.4 X, or X is equal to 4,000,000 ÷ 2387.4, or 1675 amp. This is the amount of current flowing in each line of your generator when the machine is delivering 4000 kw. and the power factor is 60 per cent.

Assuming conditions alike in each case—that is, assuming that the efficiency of the machine remains constant—the increase in steam and amount will then be in the ratio of the increase in current flow; that is, in the ratio of 1255 to 1675, or as 1 is to 1.33. This indicates that, if you have a power factor of 60 per cent, and the machine is delivering 4000 kw., there will be an increase of 33 per cent in the steam consumption over the consumption in steam when the machine is delivering 4000 kw. and the power factor is 80 per cent.

Keeping the Plant in Order

I HAVE lately taken charge of a plant which is much the worse for lack of care and should like your advice on the following:

1. Part of the switchboard is of old marble, while the remainder is of newer marble—quite a contrast in color. What can be used to clean it so that it will all look alike?

2. There is much brass, which tarnishes easily after being polished. What can be used to keep it from tarnishing so readily?

3. After the steel work is polished, what can it be covered with to present that neat appearance seen in so many of the old time engine rooms? T. G. F.

ANSWERS

OLD MARBLE can ordinarily be cleaned with soap and water. If any stains remain after the marble is washed, a weak solution of oxalic acid may be used but it should be washed off quickly and thoroughly with water to prevent injury to the surface of the marble.

Another mixture, the formula for which is given in Henley's Book of Formulas, is four parts soft soap, four parts whiting, one part sodium bicarbonate (saleratus or baking soda) and two parts copper sulphate (blue vitriol). This mixture should be left on for some time and on removal, by washing with water, the marble will be found to be perfectly clean.

2. Brass work, after having been polished, may be prevented from tarnishing by applying a lacquer made as follows:

Mix together ¼ oz. annatto, ¼ oz. saffron and 1 oz. turmeric in 1 pt. of alcohol and allow this solution to stand for several days, then strain into a bottle containing 3 oz. of seed lac, cork it and shake it to dissolve the seed lac.

3. The best finish for steel work, unless the steel is subjected to considerable moisture in the atmosphere, is an oil polish. The neat appearance which you refer to in many old-time engine rooms is the result of continual polish with oily cloths. As a rule, steel work is not lacquered; but there are on the market a number of colorless cold lacquers which would be suitable for covering this class of work, the formulas of which we do not know.

Horsepower Required to Drive a Generator

PLEASE tell me how much engine horsepower is required to drive a 100-kw. generator with a 20, 25 and 30-amp. load. The generator is a 2300-v. 25-amp. 60-cycle machine 3-phase, speed 900 r.p.m. with rotating field and belt driven.

Is the 25-amp. the overload or full load rating?

We do not know the power factor, but the load is lighting, 115 v. single phase. J. B.

A. For a 100-kw. 3-phase machine at 2300 v., the rate would be 25 amp. at full load with a power factor of one. In the loading that you have with 20, 25 and 30 amp. on the various lines, you will have practically the same output as if there were 25 amp on each line. This would give you 100 kw. or 100,000 w. delivered if the power factor were one. for a lighting load single phase, but it is likely that this will be about 0.95.

To find the horsepower delivered, you would then have 100,000 times 0.95 divided by 746 and, assuming the total efficiency for the generator of 90 per cent, you would also divide the quotient obtained by 0.90, which would give you 141½ hp. required to drive the generator.

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Providing for Continuity of Service

The success of our present-day industries is to a great extent dependent upon the continuous and uninterrupted functioning of the agencies of power production and transmission employed. Enormous losses may be sustained not only through the idleness of employes, but also through the suspension of refined and costly processes and it is therefore imperative in designing systems for the generation and distribution of power that all means possible be utilized to prevent such an occurrence.

Installation of duplicate pieces of apparatus each of sufficient capacity to supply the needs of the plant when fully loaded, while a probable solution, is not always desirable, particularly so because of the added capital investment and maintenance costs involved not only for the equipment actually required in the production of power, but also for land and buildings. Fortunately, however, other means more practicable are available. Without materially affecting the over-all efficiency of the generating plant, study of local conditions and requirements of the service will frequently reveal ways and means whereby units of such capacity rating may be installed as will allow the continuous operation of at least some of the equipment. Perhaps not sufficient to provide for the working of the entire establishment—should for some reason other parts of it become temporarily inoperative—but at least to prevent a complete shutdown with its dire consequences.

Because of the inherent characteristics of some of the apparatus comprising the equipment of a power plant this scheme has already been in general force for some time in the majority of plants, especially those of medium or large size. Undoubtedly a single boiler would in many plants suffice to meet all requirements for steam, but few engineers would care either to advise the installation of one steam generating unit or assume the responsibility for its continuous operation.

True it may be that some of the largest and most modern power plants contain but one electric generating unit. A two-fold reason for this exists. The turbine of today is a most reliable piece of apparatus. Should a unit, however, become inoperative provision has invariably been made through interconnection of the transmission and distribution systems whereby other plants are caused to pick up the load, the transfer generally being possible without service interruption or even system disturbance.

Similarly, in connection with transmission and distribution, duplex systems, the employment of feeders or tie-ins will, as a rule, serve to maintain a continuous supply of energy. And while in a majority of instances such arrangements are bound to involve a somewhat greater initial expenditure of capital, the added interest, depreciation and maintenance charges, should not with proper design exceed the losses sustained through a single shut-down of even a few moments' duration. In reality such charges resolve themselves into service insurance premiums.

Installation of equipment in excess of that required is not necessary. Solution of the problem is rather one of proper selection, arrangement and interconnection and is largely governed by local conditions and service requirements.

Remodeling Switchgears

In the rehabilitation or enlargement of power stations, the necessity of increasing the capacity of the switching equipment to conform with the other changes made, is frequently neglected or at best given scant consideration. The demand for more power is met only by the installation of additional generating units or by the substitution of equipment of a capacity greater than that in operation. Obviously then, as far as generating capacity is concerned, the problem has been solved—at least temporarily.

Where additional units have been installed switching and control apparatus for these will of necessity be included in the changes made but, where for some reason or other existing equipment has been replaced by machines of higher rating such is not always the case the presumption on the part of those in charge of the work being that as this part of the plant has heretofore rendered unfailing service, the purchase of new switching equipment would involve the unwarranted expenditure of moneys required for other and perhaps more pressing needs. That this is a short-sighted policy goes without comment. True it is that original plant design and construction may have allowed for the handling of considerably more energy than that capable of being at any time generated and as a consequence the existing switching control and plant distribution equipment which of course includes all of the various pieces of protective apparatus may remain intact with full assurance of its proper and safe operation.

Just how to determine whether or not that part of the system between the generator terminal and the outgoing lines is capable of meeting the possible demands placed upon it and the procedure to be followed in the selection of the proper equipment and its installation in the event this is found necessary are real problems liable of being encountered not only by designers and constructors but by operators as well.

Appreciating the need for concise and comprehensive information along this line on the part of many of our readers Power Plant Engineering has arranged with Stephen Q. Hayes, an expert in switchgears with the Westinghouse Electric and Manufacturing Co., to publish a series of articles the first installment of which appears in the electrical section of this issue. Years of experience have placed Mr. Hayes in a position whereby he is able to speak with authority and while his treatment of the subject is extremely thorough it is of such nature as to be of much value to the practical man. In fact, it is written from the viewpoint of a practical man for the practical man. The information imparted can be gained from experience only—or from the writings of a man of experience such as the author.

In the first installment are taken up the requirements to be considered and met and the details of construction of typical present-day oil circuit breakers. The second installment which will appear shortly is devoted to a discussion of the various types of oil circuit breakers and relays at present in use and a typical example of a relay system given, while following this will be cited the conditions existing in a rapidly growing plant and a discourse on current limiting reactors. Ways and means employed to make the necessary changes in the switching equipment of actual plants are reviewed in installments four and five.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Off Duty

We seem to be bumping into all sorts of reverse programs now. We are running turbines reversed to compress air, we pump water uphill with electric pumps, we compress gas from oil wells and gas works to get gasoline, and now, in Switzerland, they are making steam by electricity *to save fuel.* Funny idea when over here we figure that we have to burn a pound of coal to get electrical energy equivalent to one-fifth of a pound.

But in Switzerland coal and wood are scarce and costly. Beechwood costs some $28.20 per cord and coal $54 a ton, while energy from hydraulic plants is going to waste, especially during the summer and at night. By using this energy, converted to electric current, and by storing heat in boilers, it is possible to get steam cheaper than by burning fuel.

New idea that. An electric boiler. Just a water rheostat,—no smoke, no ashes, no dirt; and space,—look at these figures: A Revel "generator" (can't get away from that name when you use electricity) for about 40 hp. at 225 lb. is 24 in. diameter by 8 ft. tall. Power generated depends on voltage; it's 40 hp. at 500 v. and 22 hp. at 220 v. And it gives 2.8 lb. of steam, 97 per cent dry, per kw.-hr., which is 95.7 per cent heat efficiency.

This is no toy development, for one plant has three Revel generators using 2100 kw. at 3300 v. and making steam at 120 lb. And when they store heat energy, it is a real chunk. The storage boilers are 6 ft. 6¾ in. diameter by 34.4 ft. long and have regular bumped heads and steam dome, but no tubes. The Revel generator makes steam when off duty, and this heats water in the storage to high temperature at 195 lb. pressure during the night. Steam is used for plant processes at 30 to 45 lb. pressure, the storage boilers furnishing all the necessary supply with, sometimes, a short recharging during the noon hour.

Storage capacity is 4,000,000 B.t.u. or the equivalent of 350 lb. of coal. About 83 per cent of the electrical energy supplied by the dynamos during the charging period is returned to the plant in the steam used.

Well, we're not likely to use electrical boilers here to any extent except for shaving mugs, coffee pots, etc., for some time, but when coal gets to $54 a ton we may be glad to know that it can be done.

Yearly Index

THE INDEX for Volume XXIV of Power Plant Engineering is now prepared and will be sent free to subscribers upon request.

Cutting Belts Square

MEANS TO INSURE BETTER BELT SERVICE AND LONGER BELT LIFE. BY F. D. RICH*

HUMAN nature plays an important part in getting service and longer life out of a belt. It is human nature to do things in what seems the "easiest way," not always realizing it is often the most expensive and usually the most laborious, because it necessitates doing the work over and over again. This applies particularly in the case of cutting belting and joining it.

Cutting the ends of a belt to put it into service seems such a simple thing that often the belt man does not give it the consideration necessary to insure the best results, and much of the difficulty with otherwise good belts is due to their not being cut and joined accurately. When you know how, it is as easy to make a belt joint which will run the same as endless, as it is to do it by careless rule-of-thumb methods.

When a belt runs "wobbly" or races back and forth across the pulleys, it is not giving its best service, nor can it have its longest life. If you have a belt that is repeatedly jumping off the pulleys, you are paying

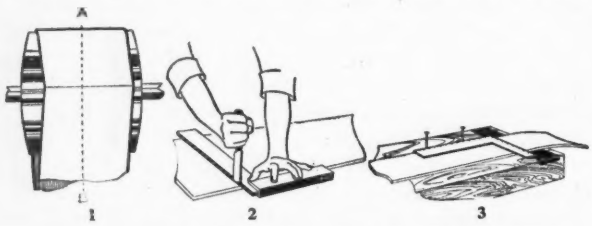

FIG. 1. A BELT JOINED THIS WAY CANNOT RUN TRUE
FIG. 2. HOLD THE SQUARE TIGHTLY AGAINST THE EDGE UNTIL YOU HAVE CUT THROUGH THE BELT
FIG. 3. THIS SIMPLE STUNT MAKES SQUARE CUTTING EASY AND POSITIVE

about twice as much as you should for it, because its life is being shortened and you are paying for power that is lost and production that you don't get. You are also repeatedly paying for unnecessary time and labor in fixing things up.

Provided that its ends are cut square and it is joined with care, a belt can be made to run as straight as an arrow if the pulleys are lined up true.

Don't guess at cutting your belt ends. Use a square —always—and use it with care. If you do not use a square, one or both of the ends will be cut unevenly or irregularly, which prevents smooth running. Even the use of a straightedge does not assure the perfect results obtained by using a square, for the slip of a fraction of an inch will bring the belt ends together at an angle, as shown in illustration Fig. 1.

This results in the belt "shimmying" on the pulleys, which is bad for the belt and impairs its service, for as it moves from side to side, the line of direct pull, "A-B," moves from one side of the belt to the other, imposing shifting and irregular strains, which no belt can stand indefinitely.

There is only one way to assure correct results. That is to use a belt square and to keep it in place until you have cut all the way through the belt. Don't just scratch the surface and then hack through. Cutting to the square assures an even cut all the way through the belt and all the way across. It means that the belt

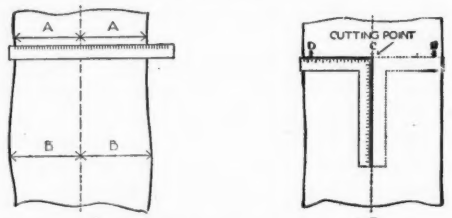

FIG. 4. FIND CENTER BY MEASURING IN FROM EDGES
FIG. 5. SQUARE BY WORKING FROM THE CENTER LINE

ends can be brought together in a tight, butt, evenly-running, flush joint.

For belts up to 15 or 18 in. wide you can use the ordinary square. Press it firmly against the edge of the belt, and, when cutting, hold the knife vertically. See Fig. 2.

Be sure your knife is sharp. Wet the point of your knife occasionally, as it cuts more easily when the blade is wet.

When a number of belts have to be cut, a good idea is to drive two nails in a large block of wood, and against these set the edge of the belt and the edge of

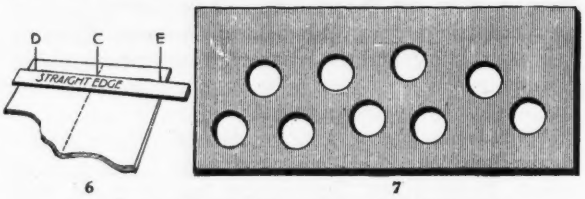

FIG. 6. ON WIDE BELTS USE A STRAIGHTEDGE
FIG. 7. EXAMPLE OF PUNCHING JOB AS ORDINARILY DONE IN THE RUSH OF WORK

the square, as shown in Fig. 3. This prevents either the belt or the square slipping. Some men tack a slip of leather or a piece of old belt on the end of the block to protect the point of the knife as it comes through the belt.

Wide belts are more difficult to square correctly, and the difficulty is often increased by slight variations in width, which throws the square out. To avoid this and assure perfect results, the method described below has proven the best.

At any point near where you are going to cut the belt, measure across and find the center, as at "A-A," Fig. 4. At any distance back of this, 2 or 3 ft., find the center again, as at "B-B." Between these two center points draw a clean, sharp line. This marks the center axis of the belt.

Now, as in Fig. 5, using the square against the center line, trim off the end of the belt, holding the square firmly in position while you cut all the way through.

*Engineer for Crescent Belt Fastener Co.

Two small nails driven in on the center line will keep the square from slipping.

For cutting the other end of the belt, find the center line, the same as just described. Then at any point on this line other than where your belt clamps will come, take a point "C" as in Fig. 5. Then using the square as illustrated, draw a line "D-C-E" at right angles to the axis, and all the way across from edge to edge. It is sometimes easier to draw this line by marking the points "D" and "E" and then placing a straightedge through the points "D-C-E" to draw the line. See Fig. 6. Be sure your straightedge is straight, not warped. This line "D-C-E" will constitute a "base line" to measure from after the belt is in the clamps. Do not cut on this line.

You can determine exactly where you want to cut after the clamps have been put on and the belt brought into position. Then measure forward from the line "D-E" an equal distance on each side of the belt to the cutting point. You can use calipers and measure over the belt clamp or run your ruler through the edges of the clamp. As a matter of convenience, always cut one end of the belt square and get it ready for making the joint before putting the belt into the clamp.

Remember that when you are doing a job, it is much easier to do it right than to do it over. This applies to making the completed joint as well as to cutting the belt. Therefore, it is best when joining a belt to do so in a way which is permanent and which insures the belt's most satisfactory service.

Personally, the writer, who has had considerable experience in working with belting manufacturers in solving the difficult problems of efficient belt joining, is very much opposed to methods which punch holes in the belt or which in any way cut or weaken the lengthwise, power-carrying fibers of the belt.

Any thinking man can see that no belt can give better service than its method of joining will permit and if wasteful or destructive means are employed, the strength of the belt is lessened, its service impaired and its life shortened.

It is no uncommon thing to see in journeys through manufacturing plants, laced belts in which from 40 per cent to frequently more than 70 per cent of the cross-section of the belt is removed in punched holes. How in the name of common sense can such a belt joint be expected to give the full service of the belt? Many manufacturers are today running belts much heavier and more expensive than their requirements, in an attempt to get strength at the joint.

There are many types of metal fasteners in common use, which from an engineering standpoint are but slightly, if any more satisfactory than lacing methods for several reasons. First, because many of them sever the lengthwise, power-carrying fibers. Second, because others place all the strain in a straight line comparatively close to the end of the belt. Third, because some make a joint which is so stiff and hard that they pound on the pulleys and cause the belt to break back of the joint. Fourth, because many put metal in contact with the pulleys, which causes noise and wears and crystallizes the metal, so that such joints must be constantly watched, both to prevent danger to workmen and failure of the joint.

The ideal belt joint is one which would run the same as endless without the drawbacks of difficulty in making and later shortening to take up stretch. Belting manufacturers themselves estimate that only a very small percentage of belts need to be made actually endless. Their estimates range from ½ of 1 per cent to 2 per cent as endless requirements.

It is possible to make belt joints which run the same as endless and which meet all requirements of this 98 to 99½ per cent of the belting field, without having any of the objections noted above.

Below is a table showing the qualifications of the perfect belt joint, by which any engineer can check up the comparative efficiency of his own methods.

THE 100 PER CENT EFFICIENT BELT JOINT

1. Will maintain maximum strength of belt.
2. Will avoid destruction or weakening of the lengthwise, power-carrying belt fibers.
3. Should prevent breaking the belt back of the joint.
4. Must not hammer on the pulleys.
5. Must not be subject to wear or to crystallization.
6. Will insure continuous, uninterrupted operation without supervision.
7. Hugs the pulleys tightly and insure full transmission of power.
8. Runs silently, same as endless.
9. Can be easily taken apart for removing or shortening the belt.
10. Is safe against accidents or breakdowns.
11. Must be easily and quickly made without special equipment.
12. Will last for the life of the belt.

Regardless of whatever method of joining is used, the belt should always be cut square, so that it may exert a straight line pull, and perform its function

News Notes

DR. F. G. COTTRELL, Director of the United States Bureau of Mines, handed his resignation to the President on Dec. 31, through Secretary of the Interior Payne. He leaves the bureau to take up his duties as chairman of the Division of Chemistry and Chemical Technology of the National Research Council. At the same time Secretary Payne handed to the President the appointment of H. Foster Bain, of California, as successor to Dr. Cottrell.

Mr. Bain was educated and trained as a geologist and mining engineer. He was one of Herbert Hoover's assistants in London on the Belgian relief work during the war. Before that he was editor of the Mining and Scientific Press of San Francisco, Calif., and later the editor of the Mining Magazine of London, England. He made some important mining investigations in south and central Africa and later undertook similar investigations in China. At one time he was a mine operator in Colorado and once was connected with the United States Geological Survey. Subsequently, he was the first director of the Geological Survey of Illinois.

For a time during the war Mr. Bain was assistant director of the United States Bureau of Mines, following up production and manufacture of metal products, explosives, and other chemical substances for war pur-

poses. At the close of the war, Mr. Bain returned to private life.

Mr. Bain was born at Seymour, Ind. Graduating from Moore's Hill College, Indiana, in 1890, he spent two years at Johns Hopkins University and later received his doctor's degree from the University of Chicago. He has been for many years a prominent and active member of the American Institute of Mining and Metallurgical Engineers, the Mining and Metallurgical Society of America, and the American Mining Congress.

THE HALLIDIE MACHINERY CO., L. C. Smith Building, Seattle, Wash., has been appointed representative of the Conveyors Corporation of America, Chicago, formerly the American Steam Conveyor Corporation, in the states of Washington and Oregon.

THE CHICAGO PNEUMATIC TOOL CO. announces the apointment of J. F. Huvane as eastern manager of compressor and engine sales, with headquarters at 6 East 44th St., New York, and G. C. VandenBoom as western manager of compressor and engine sales, with headquarters at 300 North Michigan Blvd., Chicago.

THE MESTA MACHINE CO., of Pittsburgh, Pa., announces the opening of a branch office at Chicago, Ill. The offices are temporarily located in the Railway Exchange Building but will be moved to permanent quarters in the McCormick Building after April 1. The Chicago office will be in charge of C. J. Mesta, second vice president of the company. W. R. Dawson and R. W. Schutte will be transferred from the Pittsburgh offices to Chicago. The Mesta Machine Co. has recently opened offices in the Singer Building, New York City, in charge of M. M. Moore, who was formerly export sales manager located at Pittsburgh. Frank A. Mesta will also be transferred from the Pittsburgh office to the New York office as assistant to Mr. Moore.

THE GRANITE FALLS Manufacturing Co., Lenoir, N. C., manufacturers of cotton goods, plan to erect a new hydroelectric power plant in the vicinity of Lenoir for works, service and general light and power service in this district.

THE DEPEW and Lancaster Light, Power & Conduit Co. has made application to the public service commission of New York for its approval of a franchise granted by the town board and for permission to construct and operate a plant to supply electricity for light, heat and power in the town of Colden, Erie county, New York.

THE B. F. GOODRICH RUBBER CO., pioneer manufacturer of mechanical rubber goods and other rubber products, is now entering upon the second half of a century of progress. The first half of the century was completed Dec. 31, the company having been incorporated Dec. 31, 1870, by Dr. Benjamin Franklin Goodrich.

Dr. Goodrich, who was a physician by profession, entered the rubber business as result of having acquired a rubber factory at Hastings-on-the-Hudson in a real estate deal. Seeking financial help, he was attracted to Akron, where a group of progressive citizens promised to back him up. He began manufacturing in a small, two-story brick building with a force of 25 employes. This small factory has grown until today it comprises 63 giant buildings covering 110 acres of ground.

In the golden anniversary greeting to employes and thousands of customers throughout the country, President B. G. Work said in part: "We feel a thrill of pride as we look back over the years and realize the part we have played in the development of the rubber industry."

The Goodrich Company commemorated the golden anniversary by publishing an attractive 48-page book called the "Golden Year of Goodrich" telling of the romance of the rubber industry, its history, and of what great importance it has been in the progress and development of the world. The book was written by Wilbur D. Nesbit and illustrated by W. T. Benda.

Trade News

FOR FIRMS interested in export trade, the Export Register, Federation of British Industries, will be found to contain much interesting matter. The Federation, founded during the war, occupies an important position in British industry and the Register explains its organization for the benefit of buyers and users of British goods, as well as giving the names of the member firms, their foreign agents and the goods manufactured. There is also a list by manufactures and products, giving the firms engaged in each line. Office of the Federation is at 39 St. James St., London, S. W. 1.

CATALOG F of Ross Heater & Mfg Co., Inc., Buffalo, N. Y., illustrates and describes the various types of heaters, condensers, expansion joints, coolers and air-jector pumps manufactured by the company.

BULLETIN No. 46,028, third edition, issued by the General Electric Co., describes a temperature indicator (for direct-current operating circuits) which gives continuously at the switchboard the operating temperature of established sections of stator windings in machines equipped with coils and terminal board. All a.c. machines of the company (a) having a stator core width of 20 in. or more, (b) of 5000 v. and over, 500 kv.a., and (c) turbo-generators of more than 500 kv.a., are furnished with imbedded temperature coils. Fluctuations in temperature of the winding cause corresponding variations in resistance of the copper resistor in contact with the insulation, from which temperature is indicated directly over a range from 20 to 120 deg. C.

The sensitive indicator is a differential D'Arsonval horizontal edgewise type and has an adjustable resistance governed by a switch covering a range of 100-130 or 200-260 v. For accuracy this resistance is set to the nearest 5-v. step on a 110-v. circuit and to the nearest 10-v. step on a 220-v. circuit.

The temperature coils are of copper wire wound on a thin form pressed flat, non-inductive and adjusted to 10 ohms at 25 deg. C. Three leads in cable are run permanently from each coil to the indicator. A set of triple-pole receptacles and special plug for connection at the switchboard and disconnecting switch for cutting off the source of supply are provided. A self-opening, pull-button test switch checks the operation of the instrument and a voltage protective device is mounted on the machine. Information required for recommendations is specified.